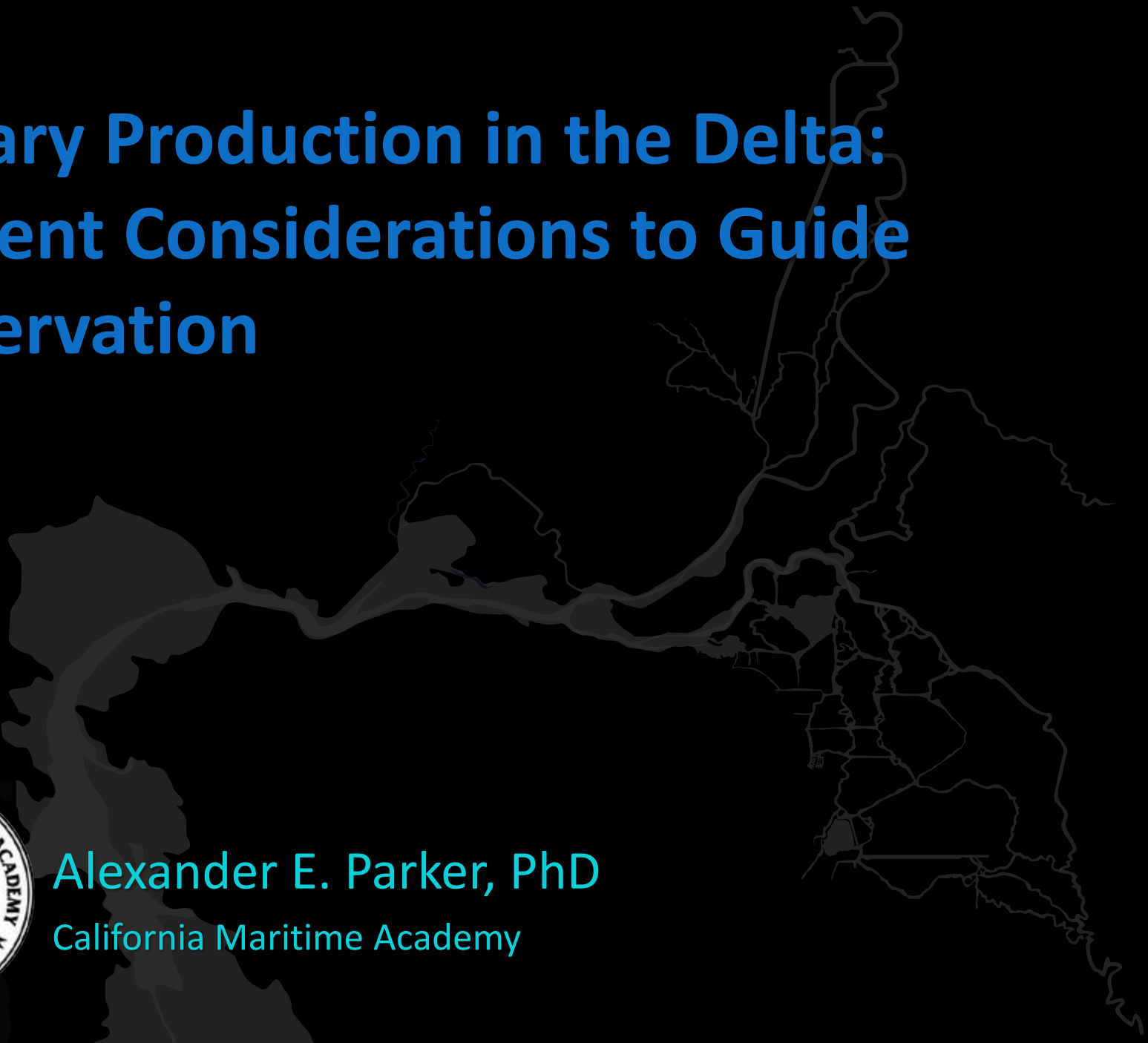
Primary Production in the Delta: Nutrient Considerations to Guide Conservation



Alexander E. Parker, PhD

California Maritime Academy

Many contributors to data collection and interpretation:

Dugdale / Wilkerson Lab

Richard Dugdale

Frances Wilkerson

Sarah Blaser

Victoria Hogue

Al Marchi

Adam Pimenta

Erica Kress

Jamie Lee

Allison Johnson

Sacramento River Study

Chris Foe

Nutrient Ratios Project

Patricia Glibert

Jeff Alexander

Microcystis Project

Hans Paerl

Tim Otten

IRWM / Suisun Marsh Studies

Risa Cohen

Suisun Bay/ SWAMP

Karen Taberski

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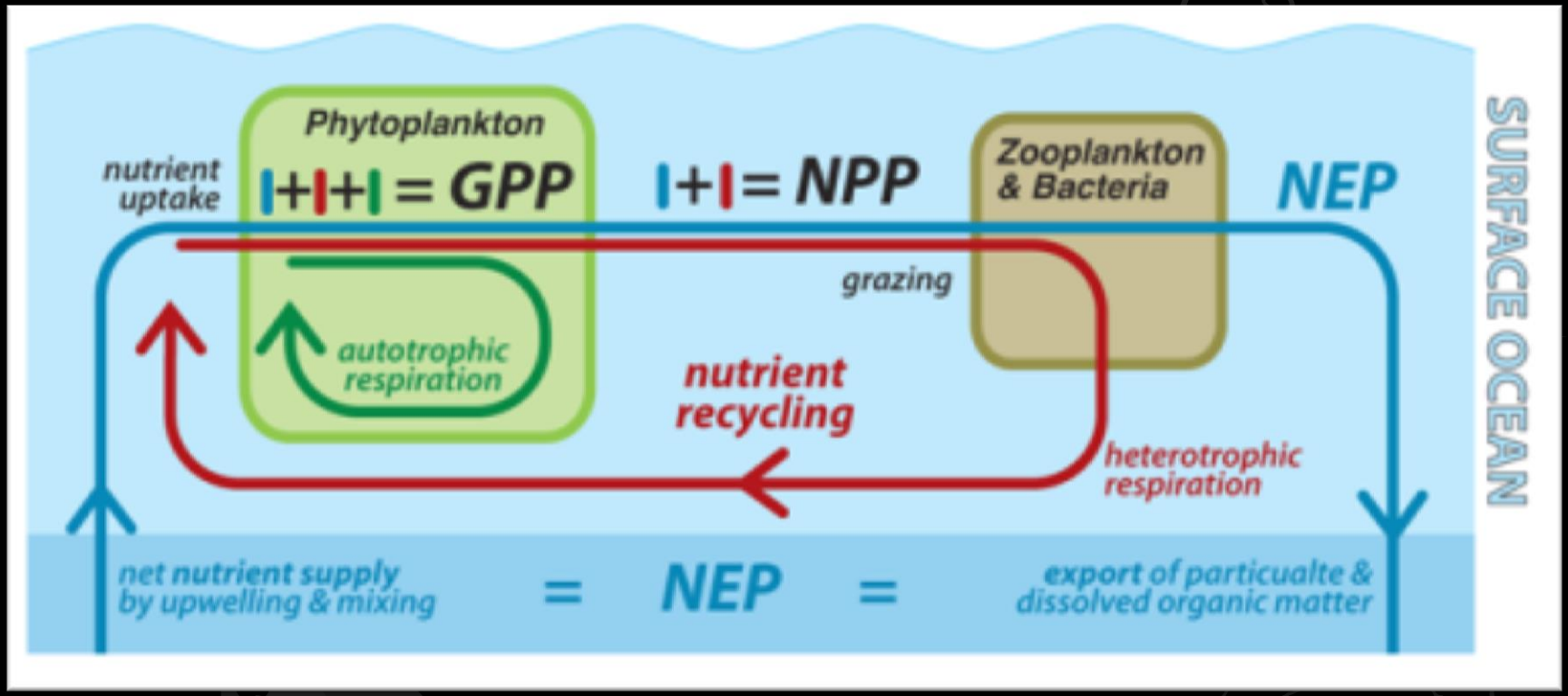
Thinking About Nutrients: The Ocean Perspective

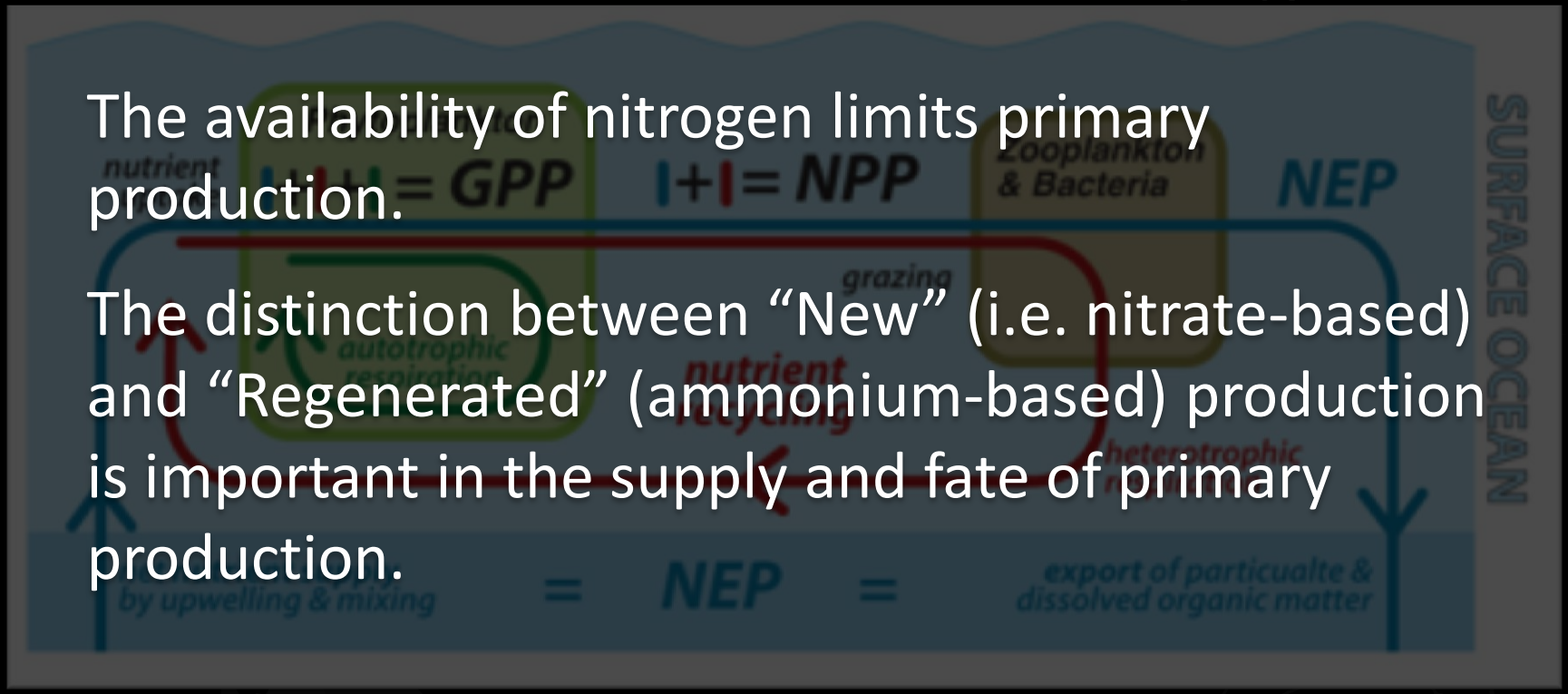


From: Sigman and Hain 2012

Thinking About Nutrients: The Ocean Perspective

The availability of nitrogen limits primary production.

The distinction between “New” (i.e. nitrate-based) and “Regenerated” (ammonium-based) production is important in the supply and fate of primary production.



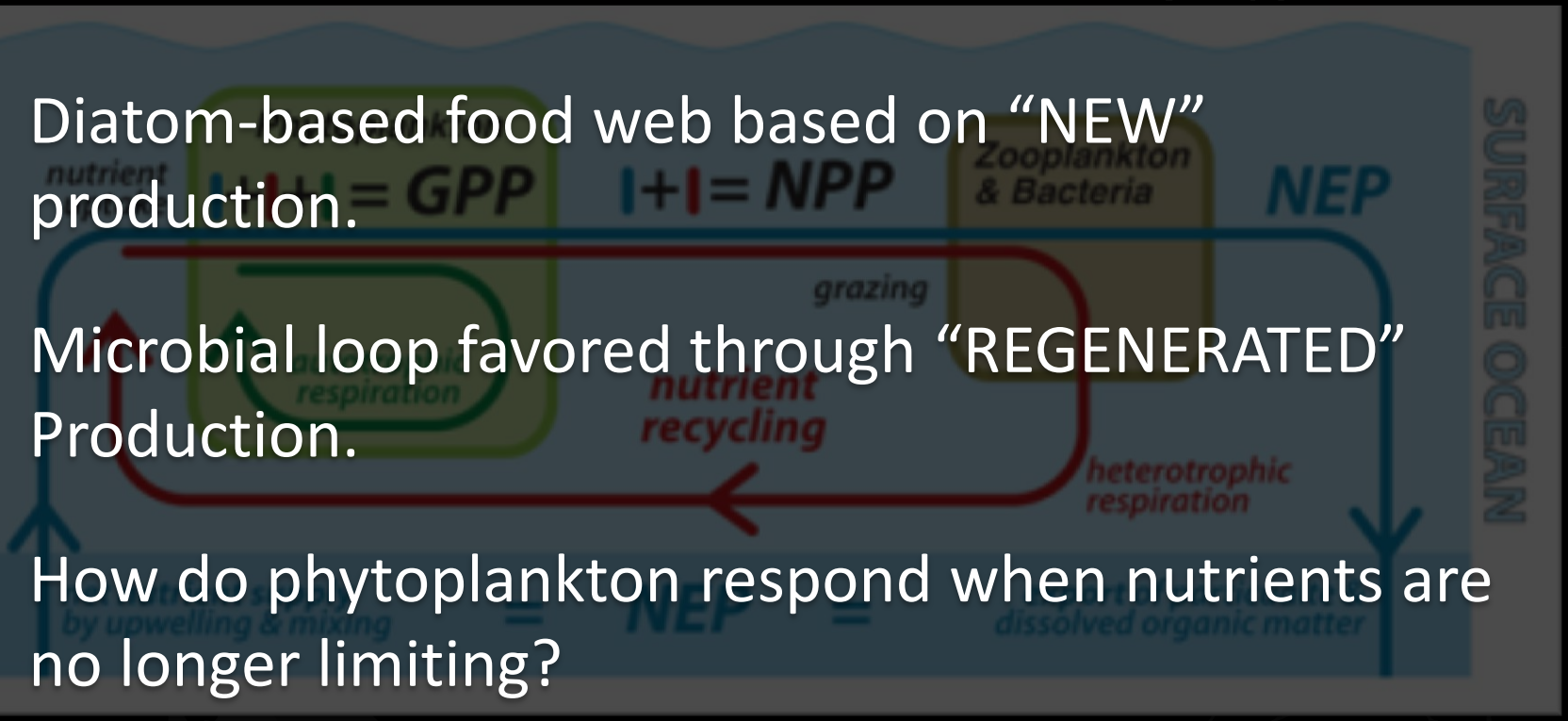
From: Sigman and Hain 2012

Thinking About Nutrients: The Ocean Perspective

Diatom-based food web based on “NEW” production.

Microbial loop favored through “REGENERATED” Production.

How do phytoplankton respond when nutrients are no longer limiting?



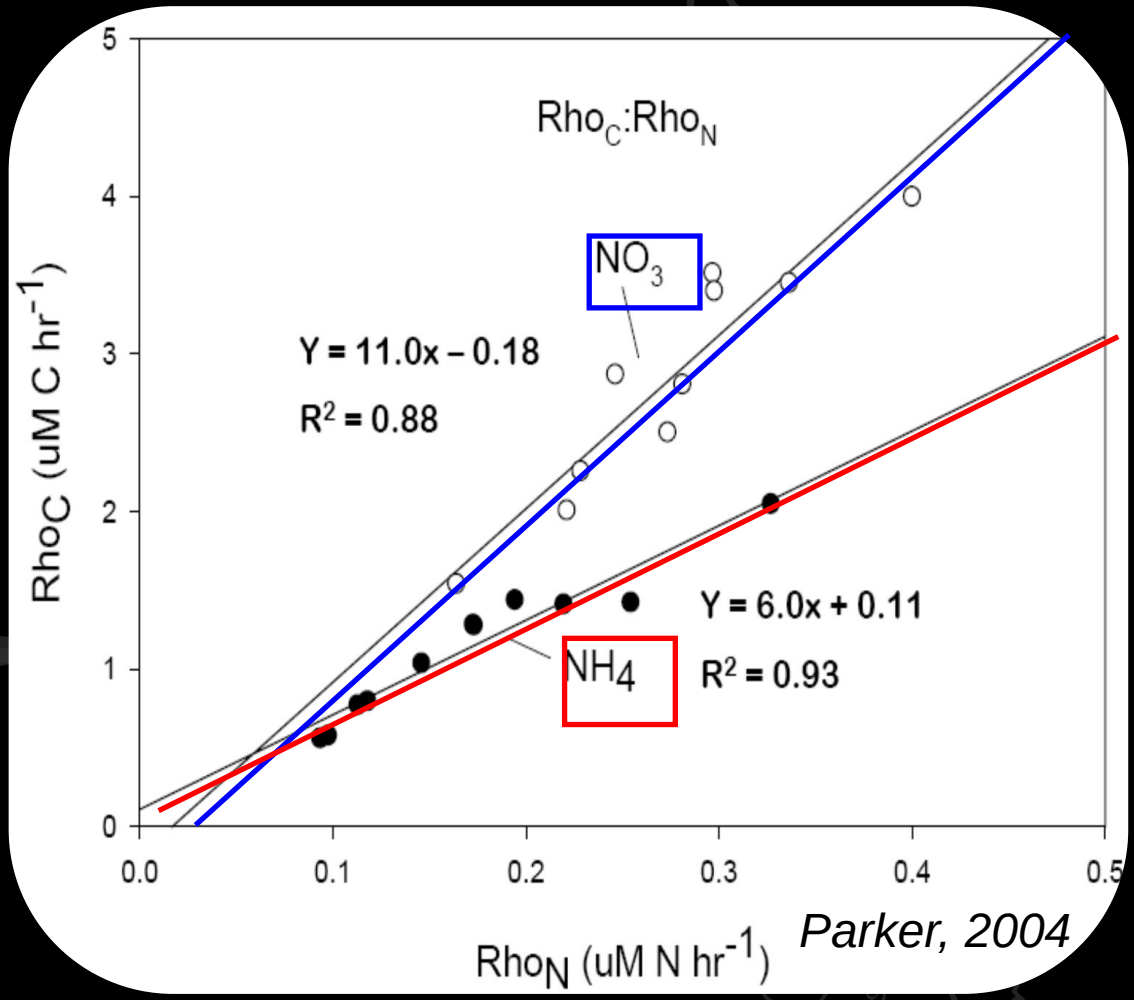
From: Sigman and Hain 2012

Phytoplankton Response to Anthropogenic Nutrients

200-L mesocosms amended with either NH_4 or NO_3 (50uM) and incubated for 72 hours.

>2-fold increase in chlorophyll-a, increase in DOC and bacterial activity

Phytoplankton Response to Anthropogenic Nutrients



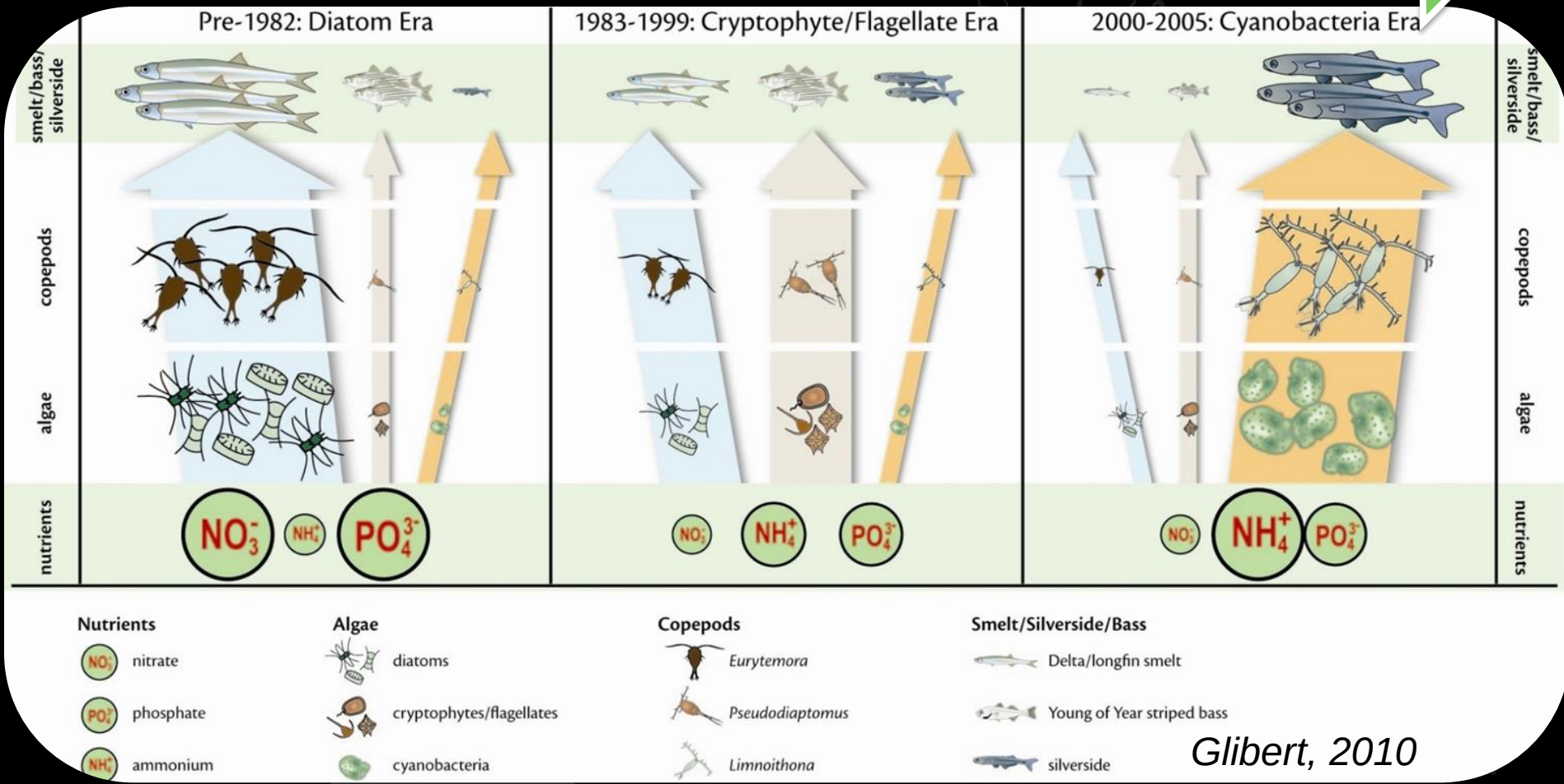
Parker, 2004

>2-fold increase in chlorophyll-a, increase in DOC and bacterial activity

Phytoplankton Response to Anthropogenic Nutrients

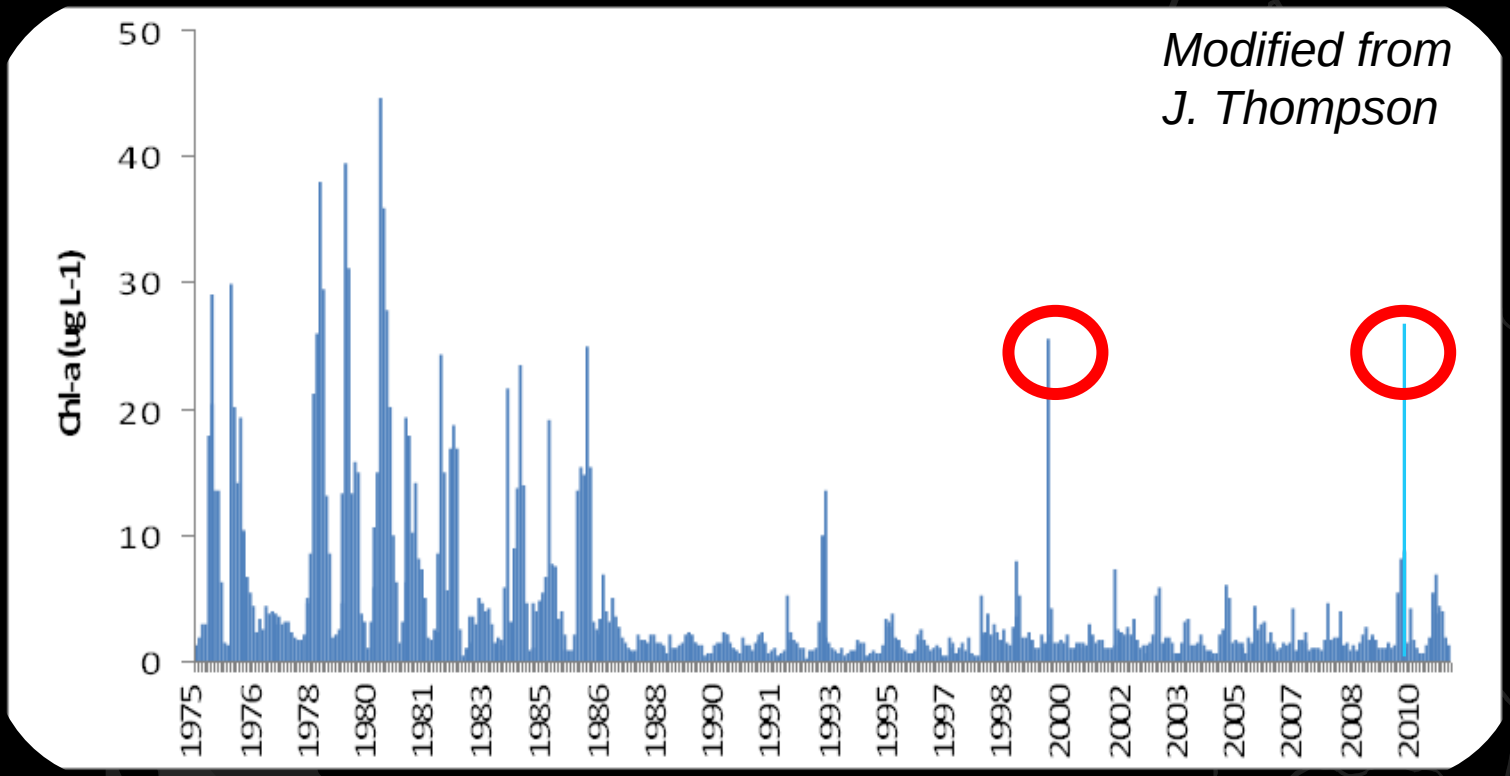
Increasing contribution by NH_4

Increasing N : P



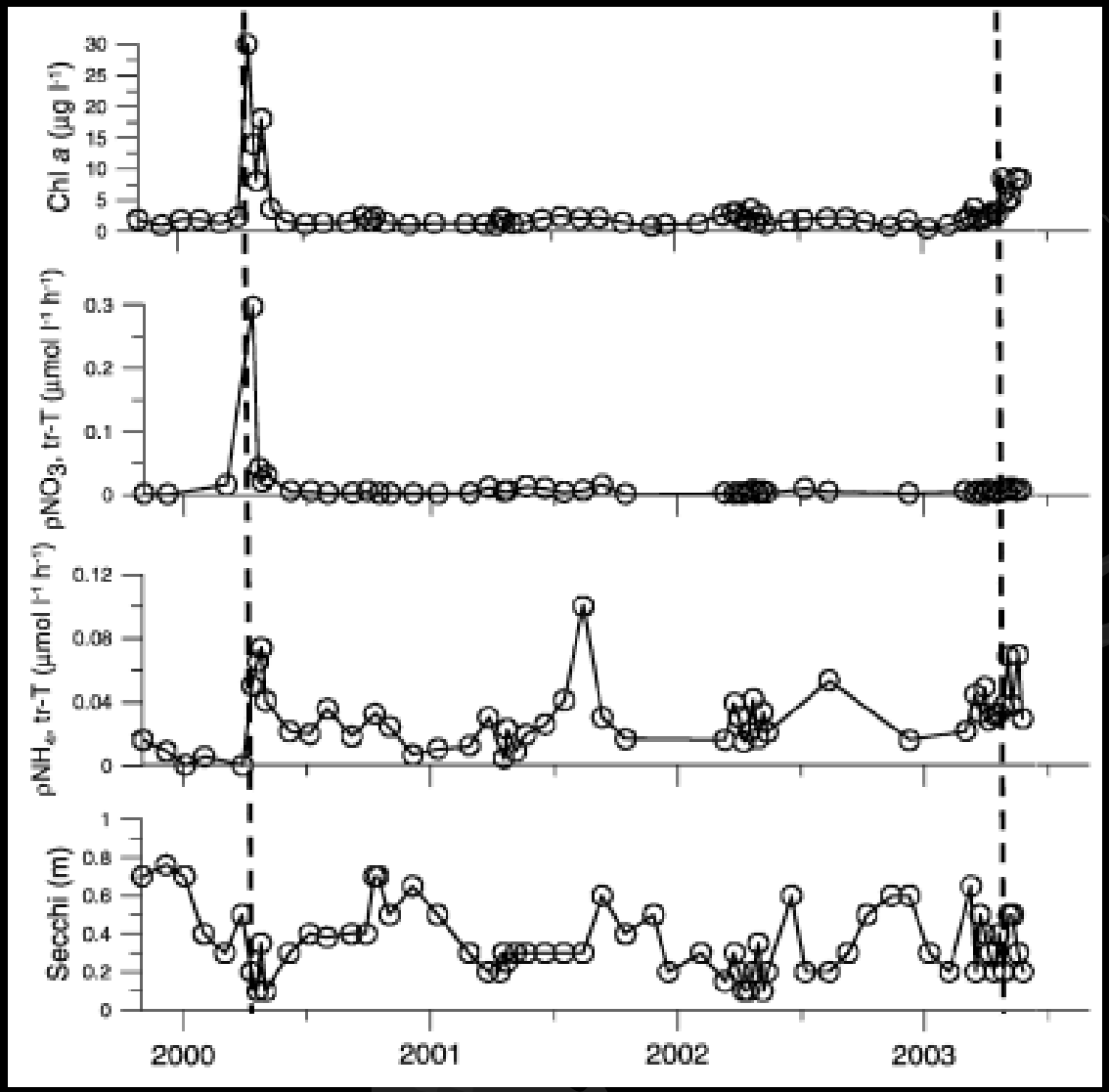
Glibert, 2010

Phytoplankton in northern SFE



Ephemeral spring and more persistent fall phytoplankton blooms in recent years.

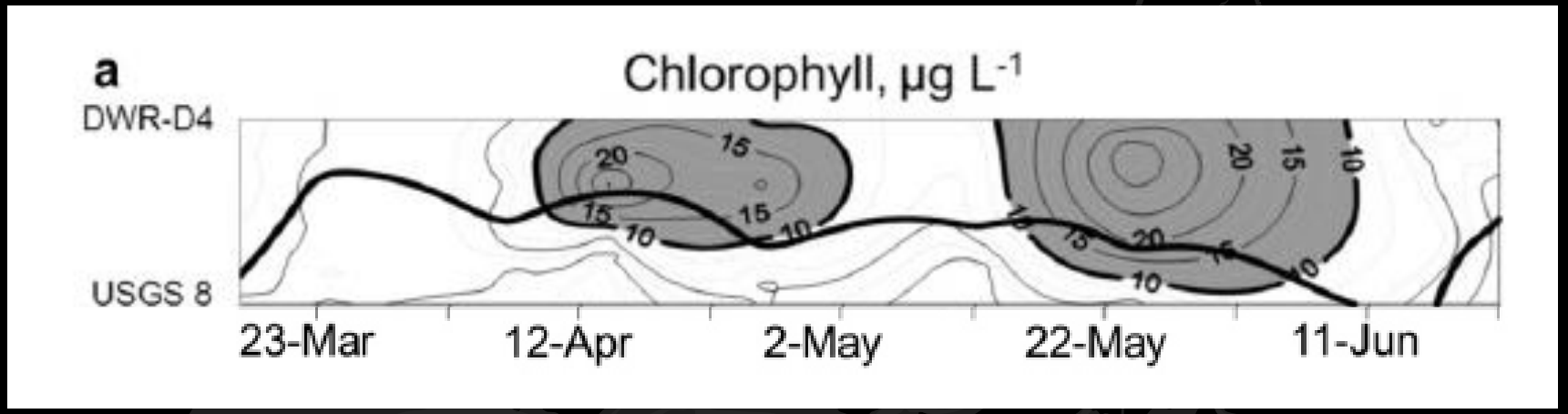
Phytoplankton in northern SFE



2000 bloom associated with an improved light field, low ammonium concentrations and rapid nitrate uptake.,

Wilkerson et al 2006

Phytoplankton in northern SFE



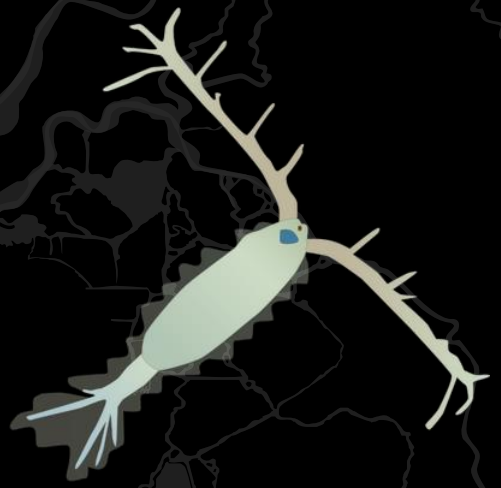
Dugdale et al 2012

2010 diatom (*Entomoneis, Cyclotella, Melosira)* blooms lasted several weeks,

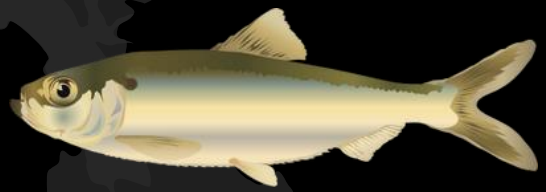
Phytoplankton in northern SFE

Phytoplankton increase 10-fold over 2009.

Zooplankton increase 9-fold over 2009



Delta smelt (70%) and longfin smelt (194%) increased (FMWT survey)



Dugdale et al 2012

What Do We Know About Nutrients in the SFE?

Long history of measurements for the San Francisco Estuary (e.g. USGS).

Main stem of Sacramento and San Joaquin Rivers.

Paradigm is that nutrients are replete / not limiting.

Primary Production in the Delta: Nutrient Considerations to Guide Conservation

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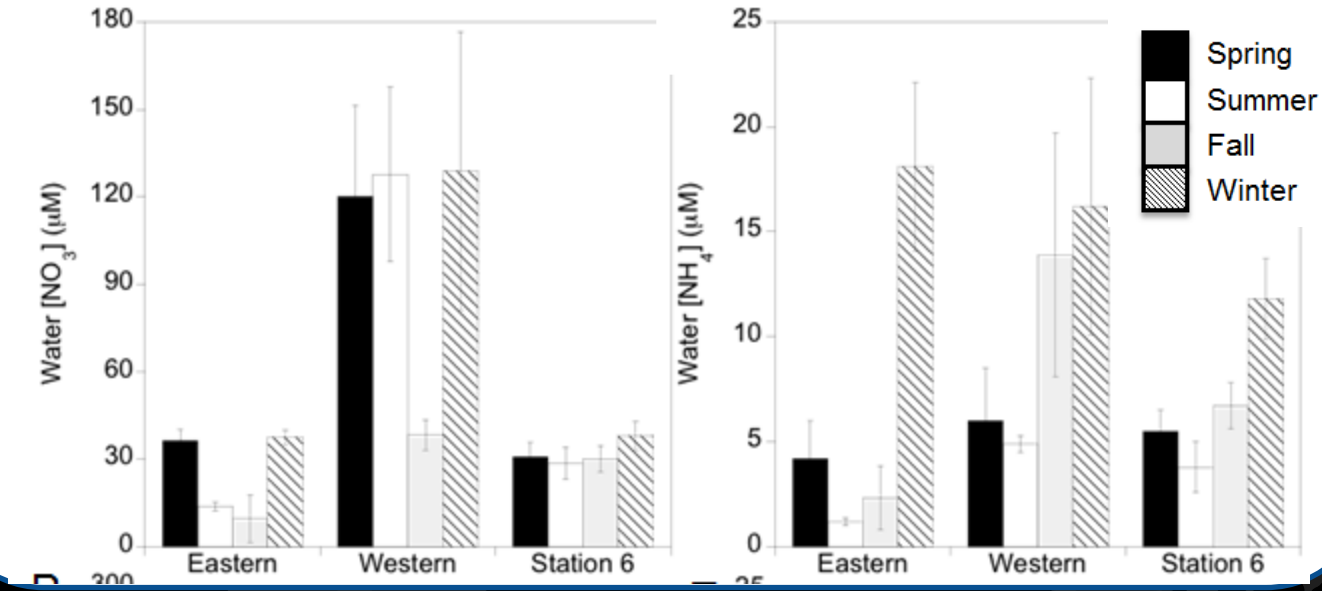
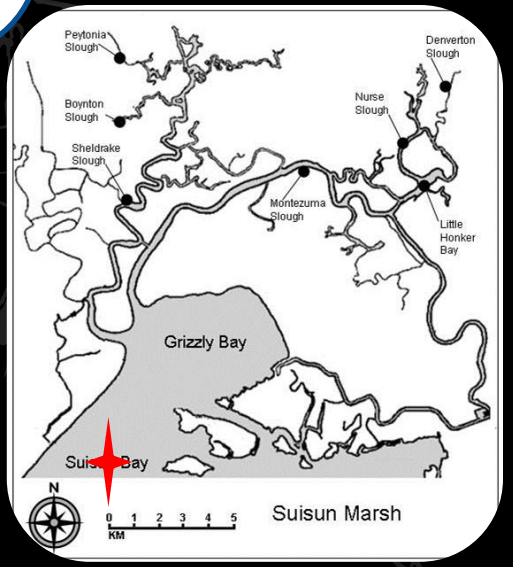
Nutrient Distribution Are Highly Variable in Space and Time in the Delta



From Parker & Cohen 2010

Western and Eastern Suisun Marsh



Large (4-fold) spatial and temporal variation in nutrients in Suisun Marsh.

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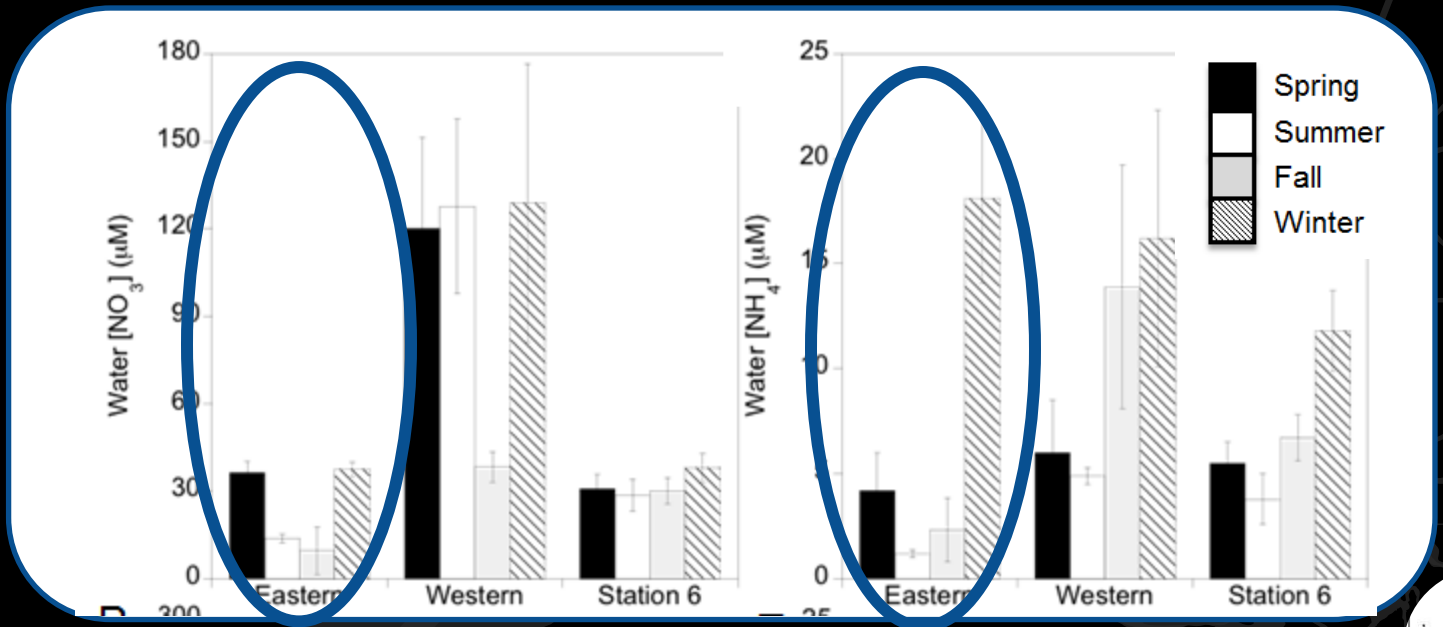

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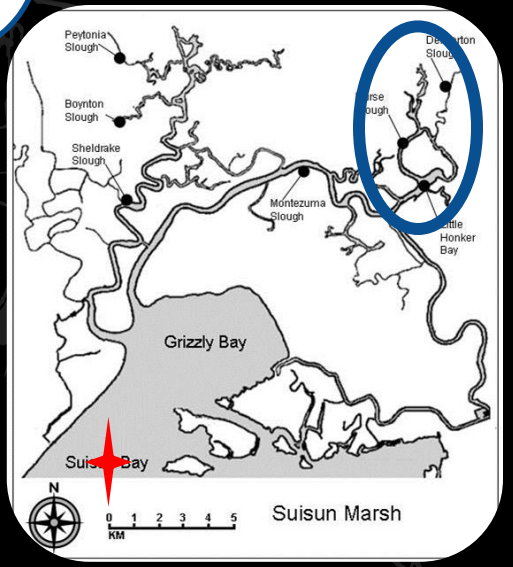

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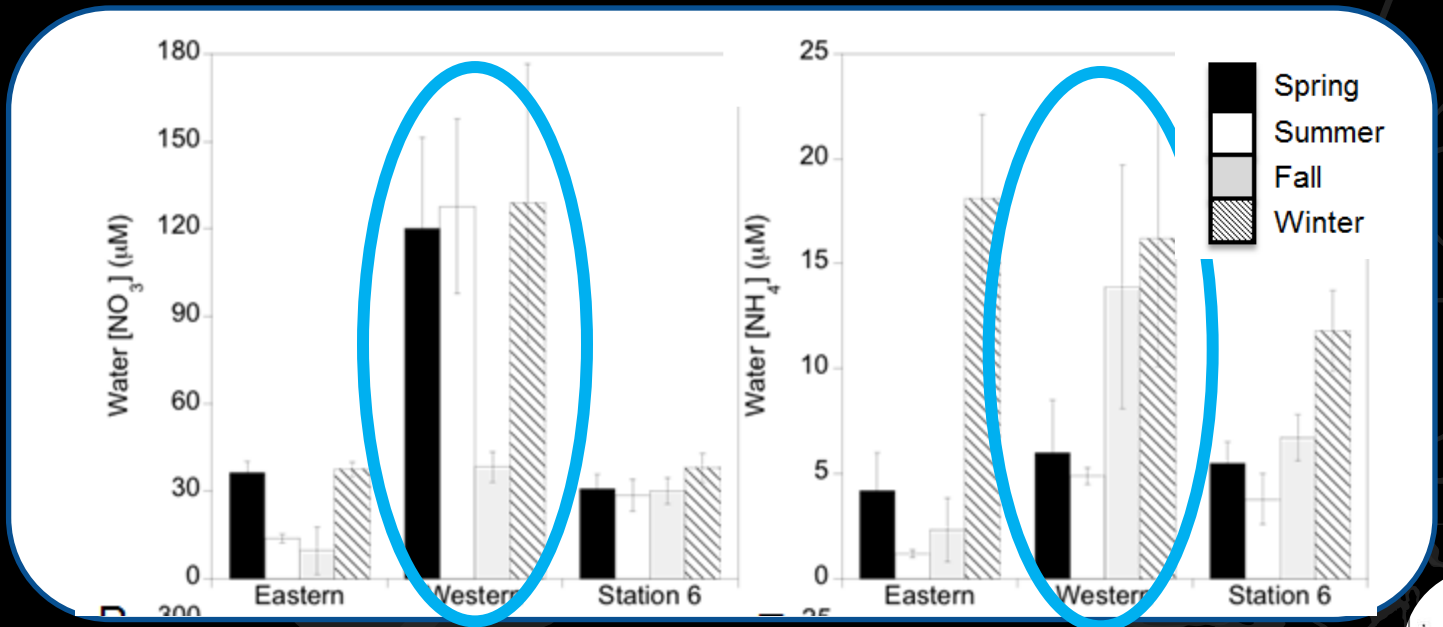

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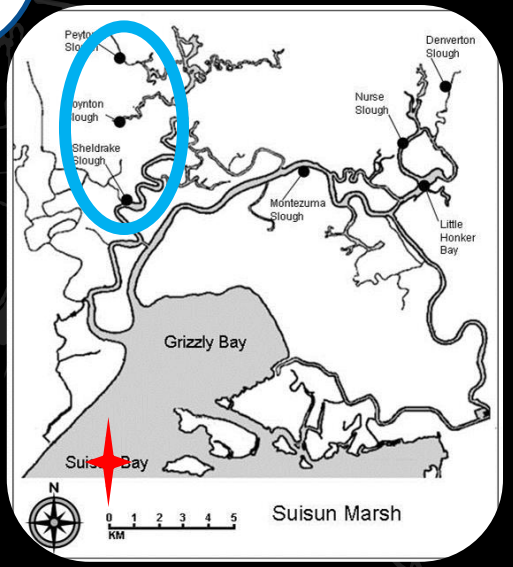

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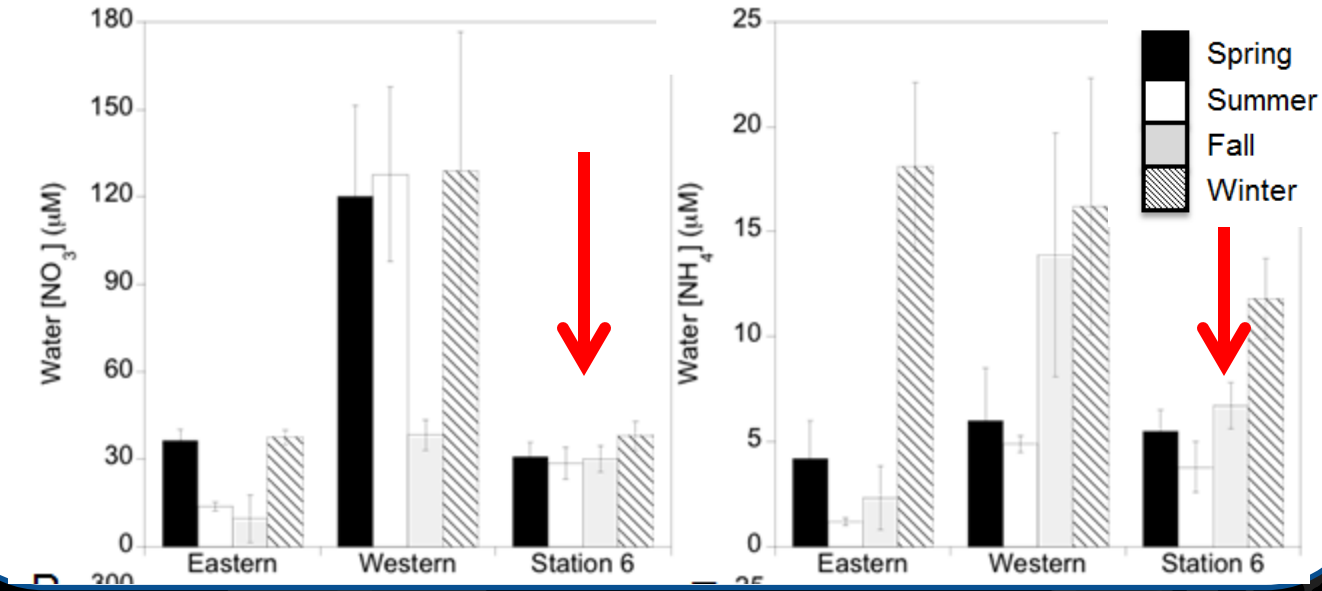

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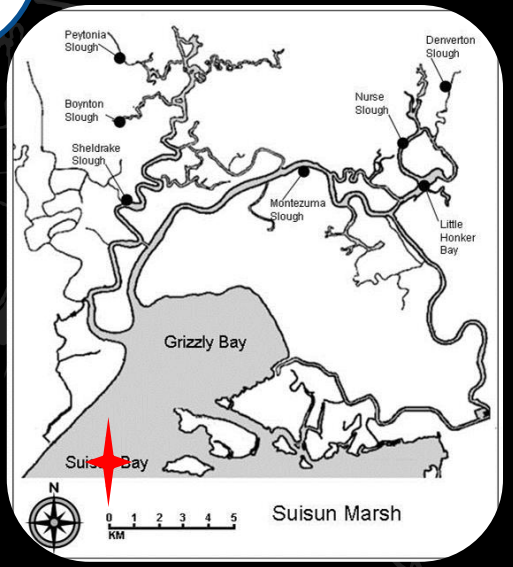

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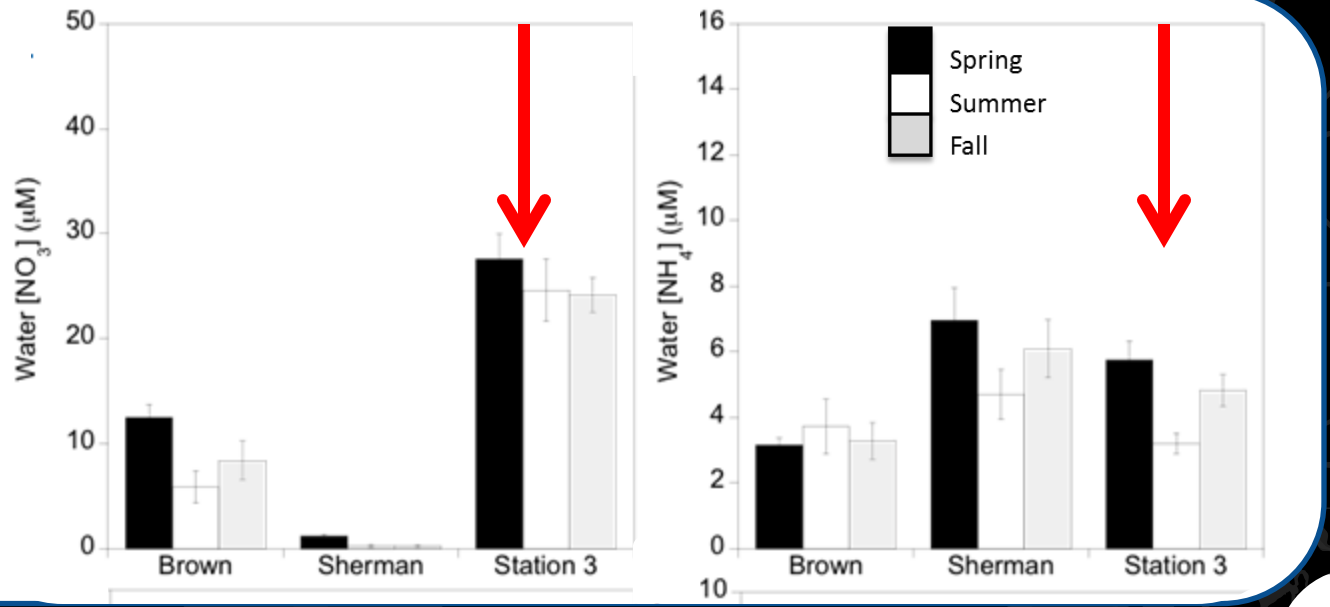
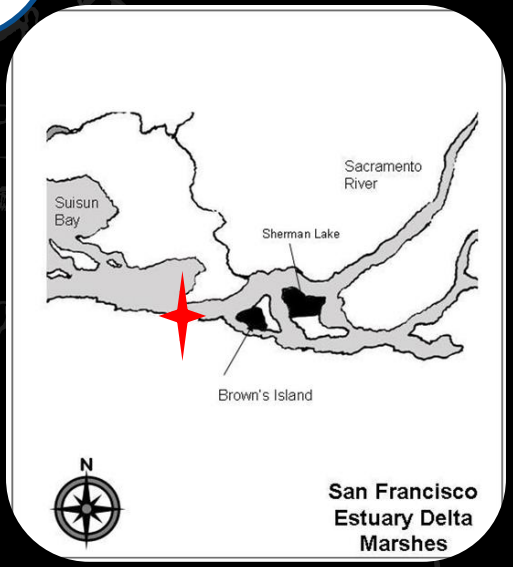
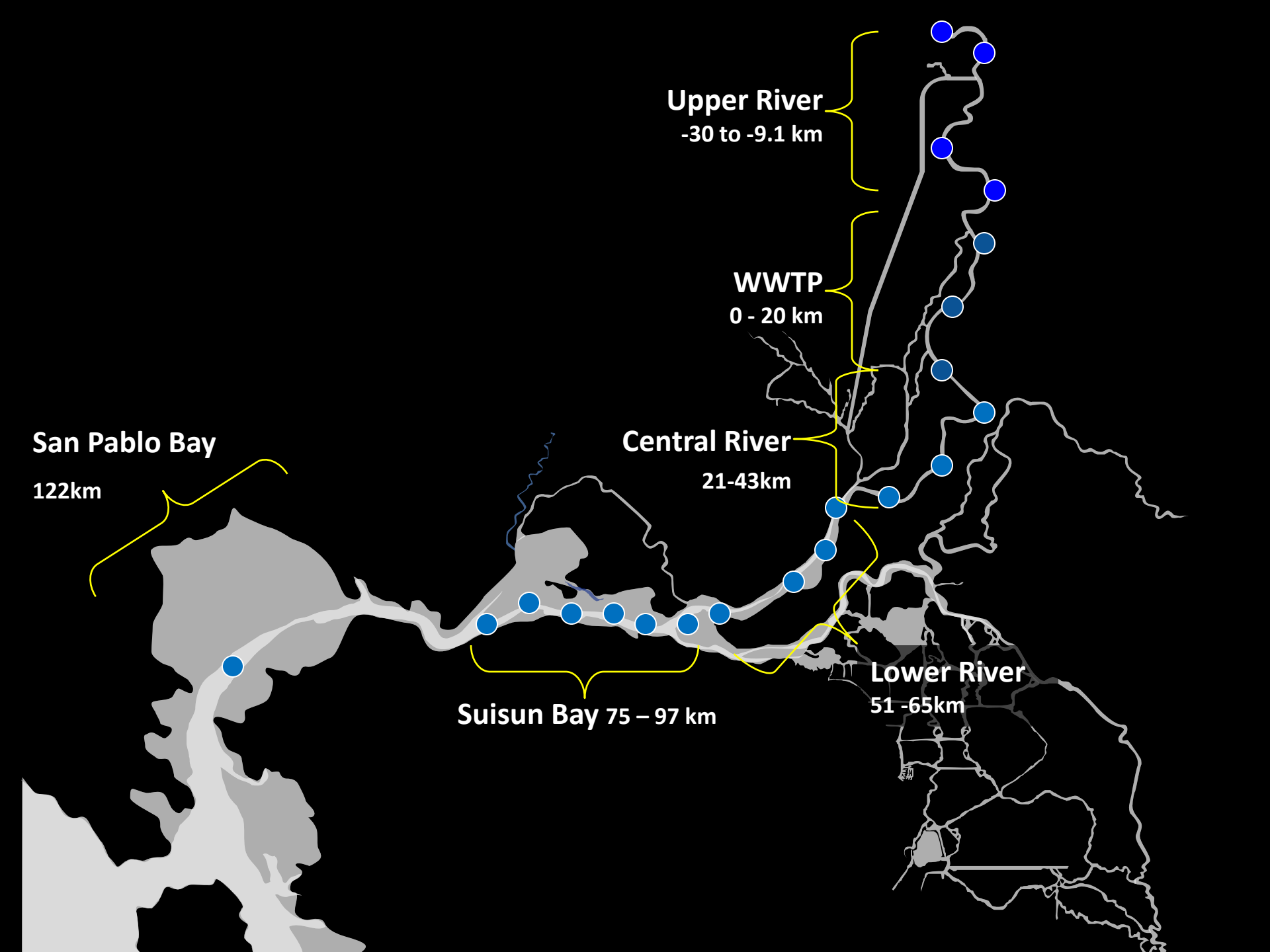


From Parker & Cohen 2010

Large (>10-fold) variation over relatively small spatial scales.

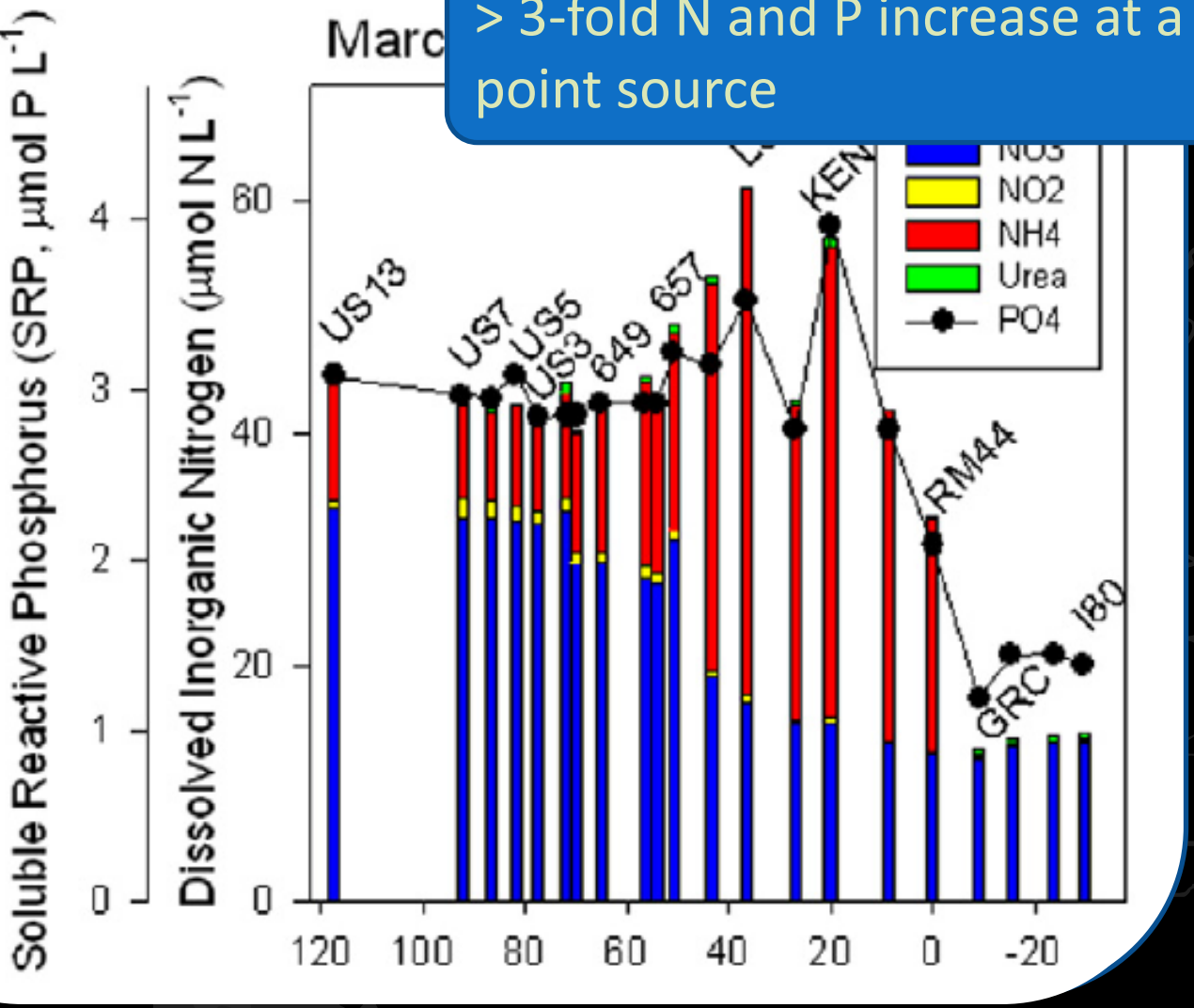
Tidal wetlands in the confluence




Upper River
-30 to -9.1 km
WWTP
0 - 20 km
Central River
21-43km
San Pablo Bay
122km
Lower River
51 -65km
Suisun Bay 75 – 97 km

Nutrient Distribution Are Highly Variable in Space and Time in the Delta

> 3-fold N and P increase at a single point source



Sacramento River

From Parker et al. 2012

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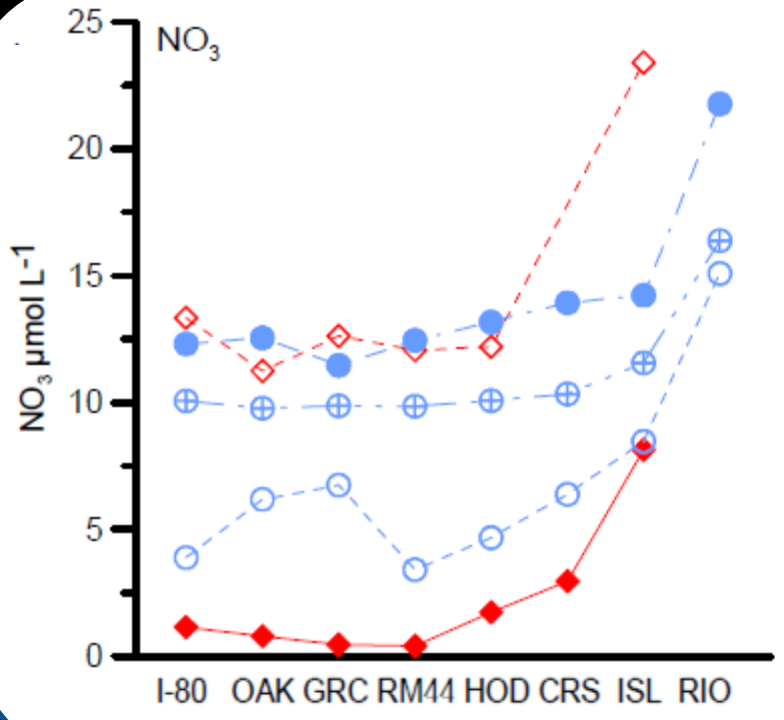

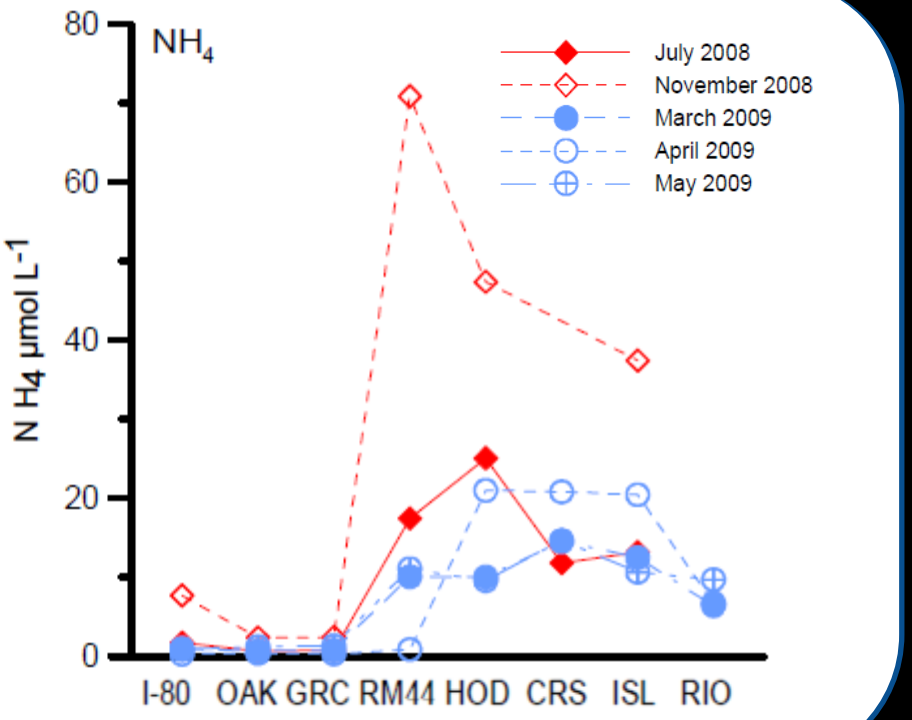

Summer N-limited in upper river and >4 fold variation in NH_4 seasonally.

Sacramento River

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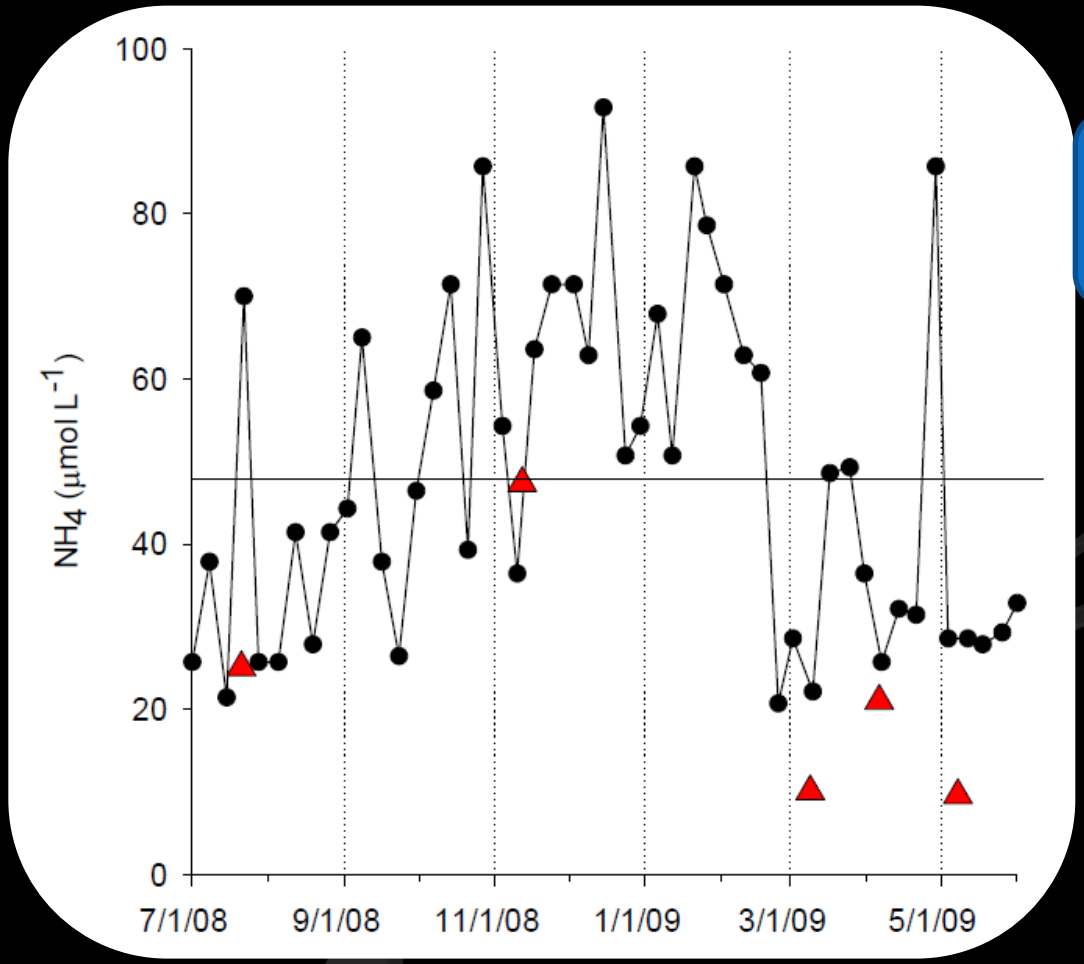


From SRWWTP, in Parker et al. 2010

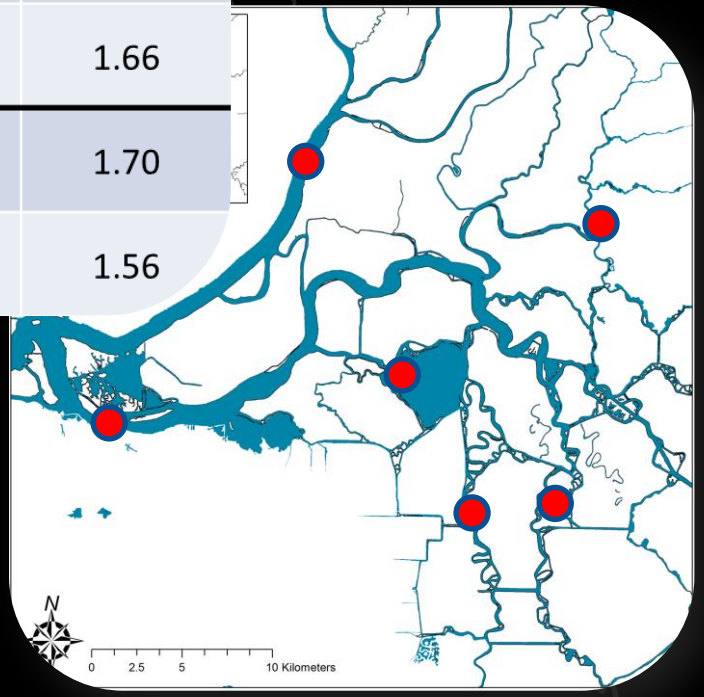
>4 fold variation in NH_4 seasonally.

Sacramento River

Nutrient Distribution Are Highly Variable in Space and Time in the Delta

	Station	Temp. C	Secchi (m)	NO_3+NO_2 ($\mu mol\ L^{-1}$)	NH_4 ($\mu mol\ L^{-1}$)	Urea-N ($\mu mol\ L^{-1}$)	PO_4 ($\mu mol\ L^{-1}$)
Large River	RIO	21.2	1.5	10.22	12.6	0.44	1.02
	ANT	21.3	0.9	12.12	1.05	0.32	1.05
Small River	MOK	21.6	1.9	9.36	3.61	0.64	0.43
	OLD	22.8	3.5	4.59	1.34	0.14	1.66
Flooded Island	MIL	23.1	2.3	21.64	0.32	0.56	1.70
	FRK	21.6	>2	10.40	1.15	0.78	1.56

Central and South Delta



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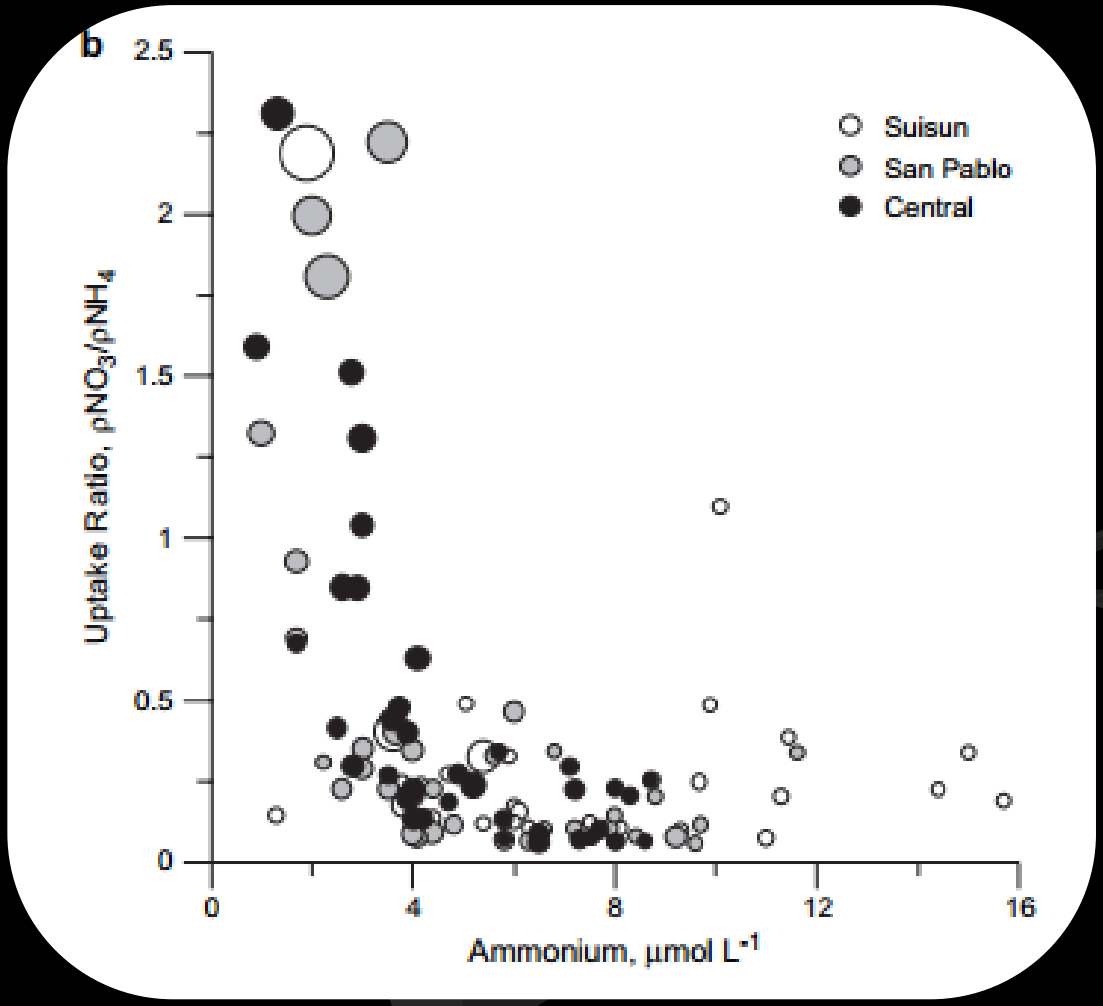
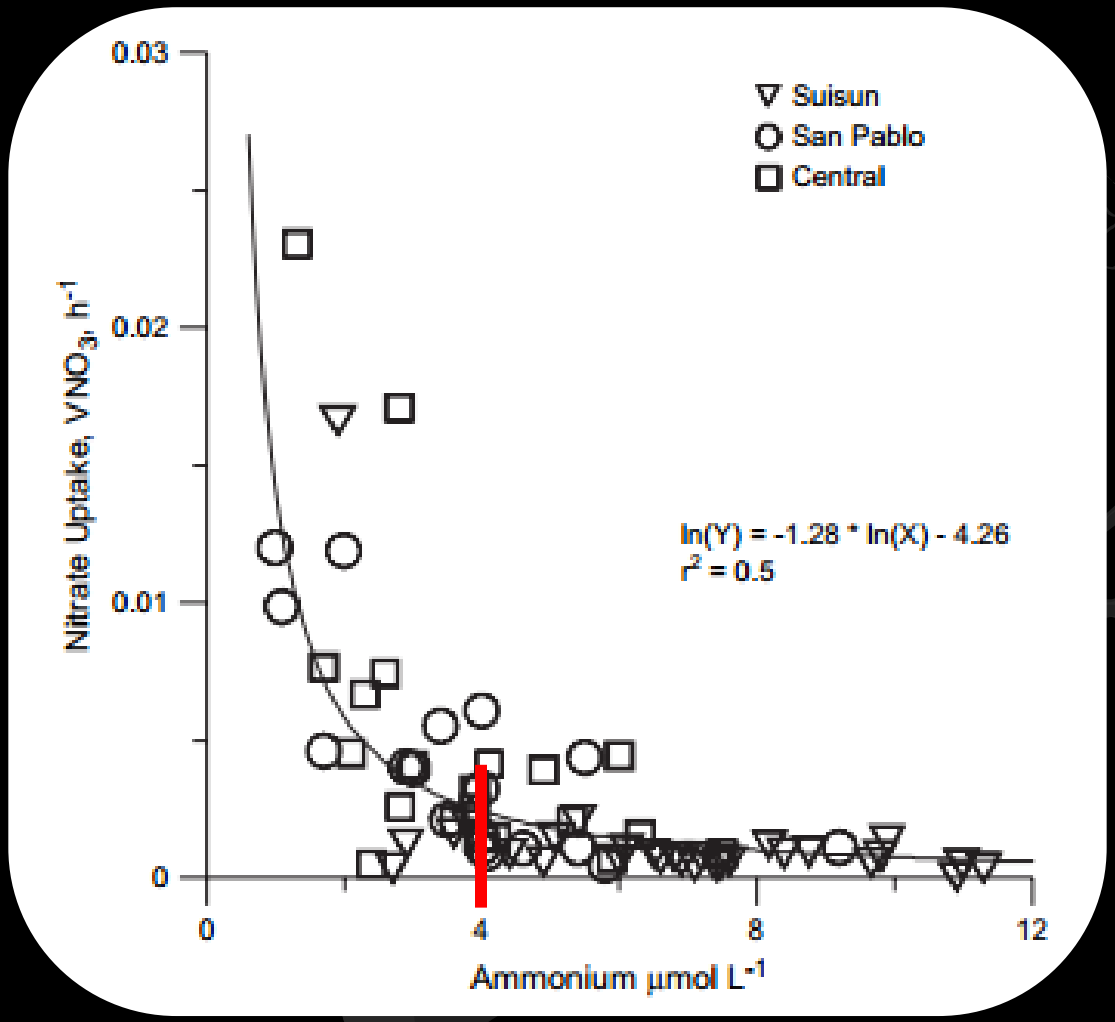


From Dugdale et al. 2007

Elevated chlorophyll-a associated with NO_3 uptake

Nutrients and Primary Production in the Delta



From Dugdale et al. 2007

Ammonium (NH_4) inhibits phytoplankton access to nitrate (NO_3)

NH_4 ≈ 4 µM (0.056 mg /L) inhibits NO_3 uptake.

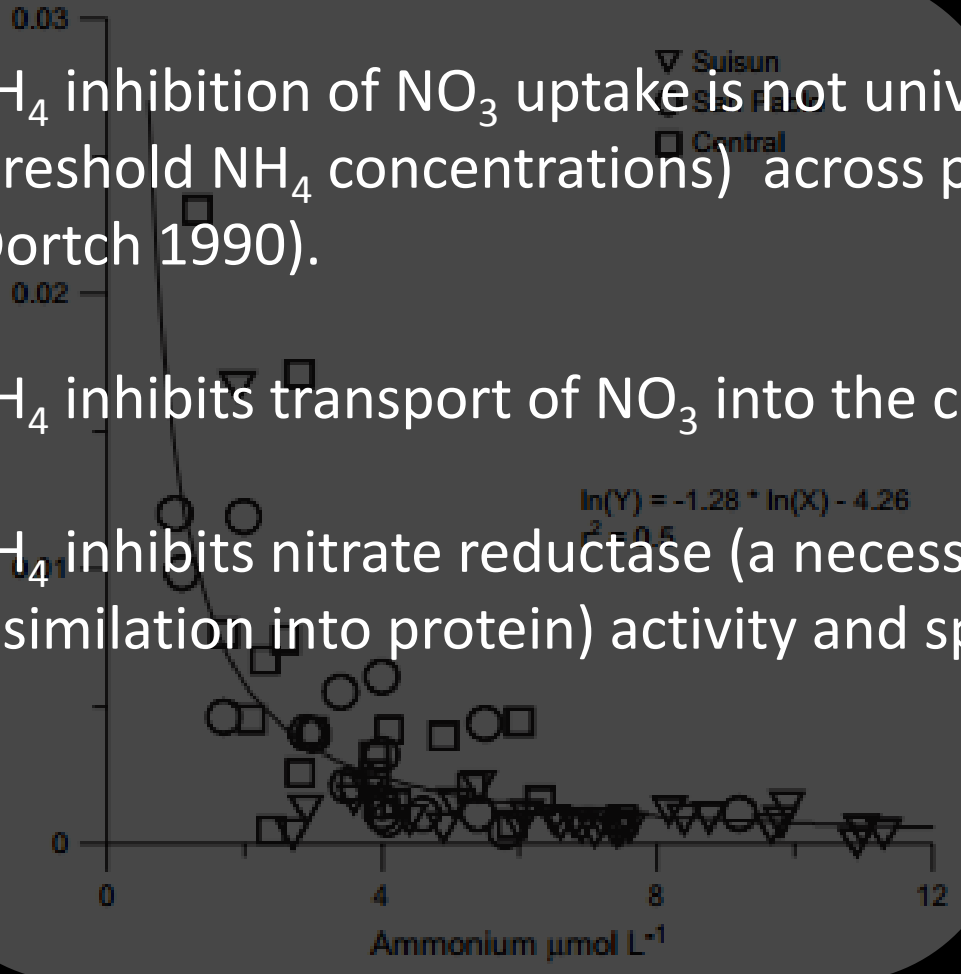
NH_4 ≈ 1 µM (0.014 mg /L) inhibits NO_3 uptake by 60%

Nutrients and Primary Production in the Delta

NH_4 inhibition of NO_3 uptake is not universal (nor are threshold NH_4 concentrations) across phytoplankton taxa (Dortch 1990).

NH_4 inhibits transport of NO_3 into the cell.

NH_4 inhibits nitrate reductase (a necessary step in NO_3 assimilation into protein) activity and specificity.



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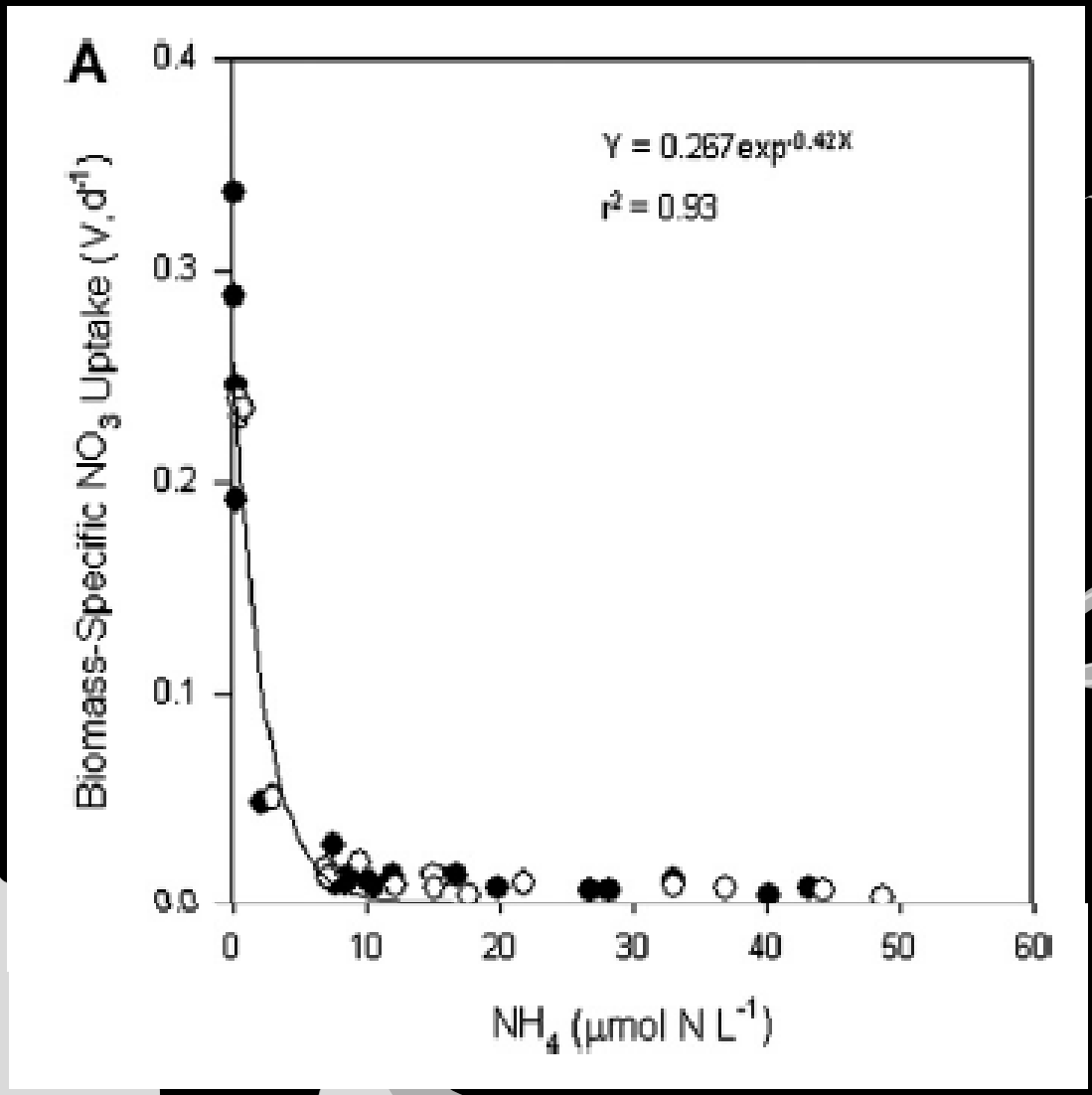

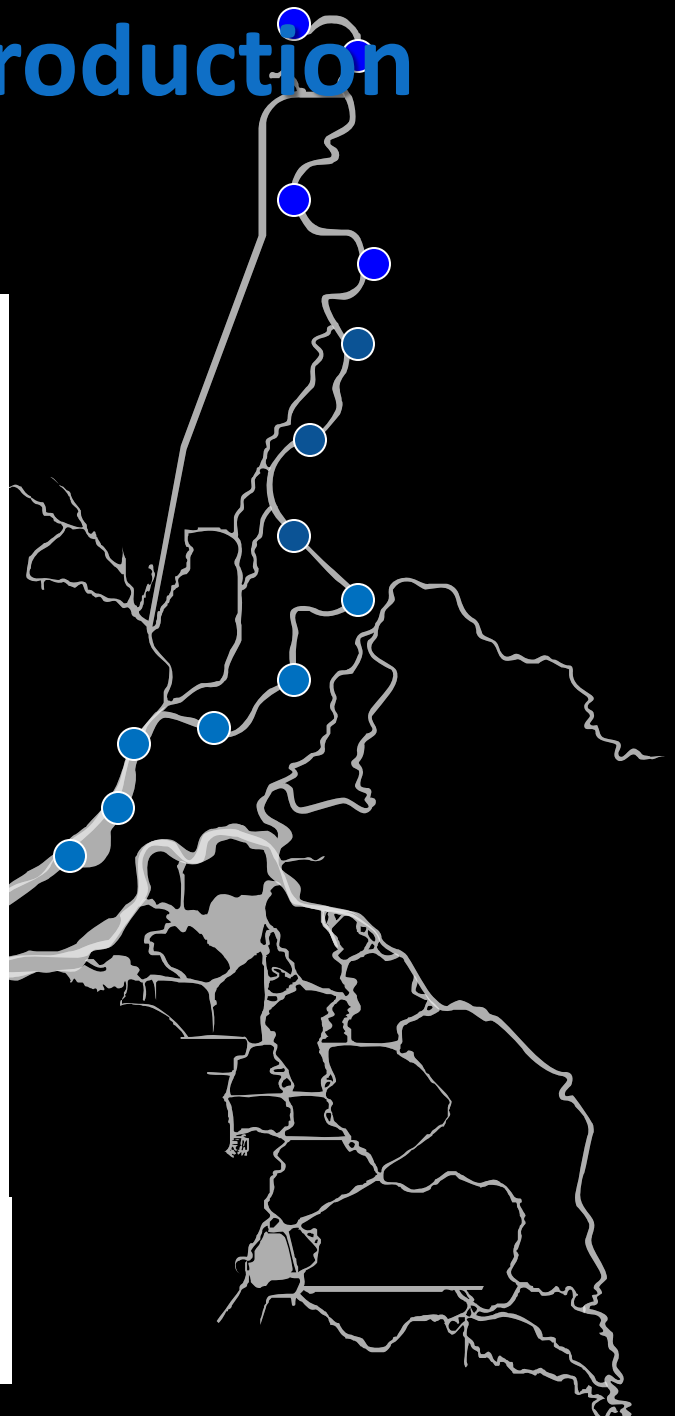

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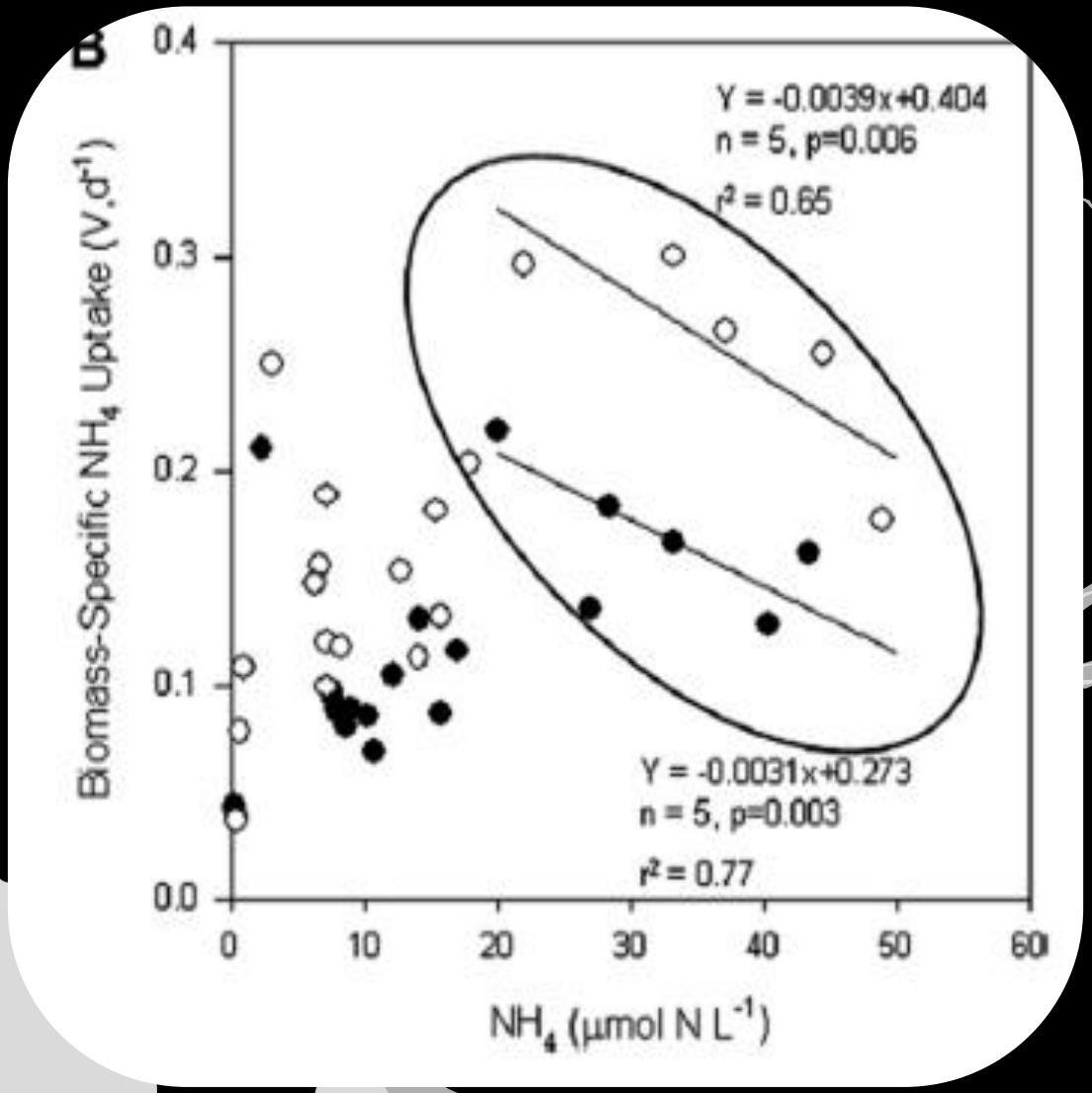
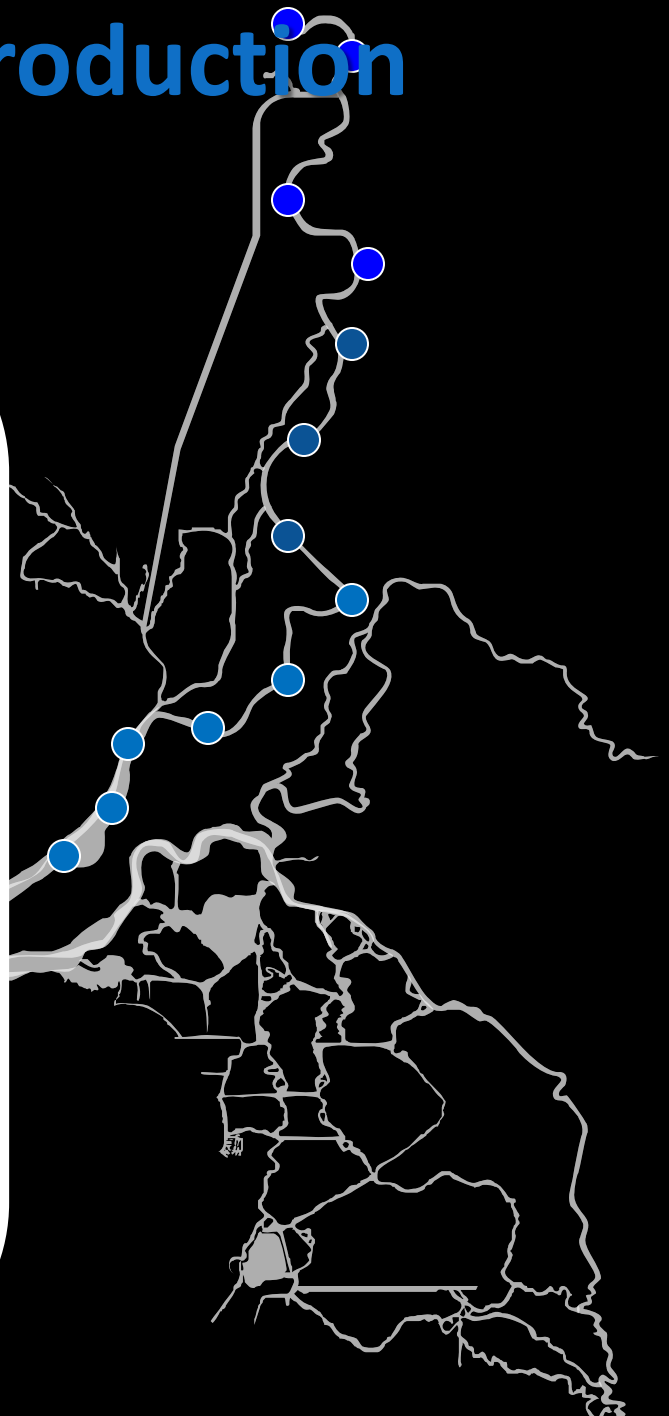
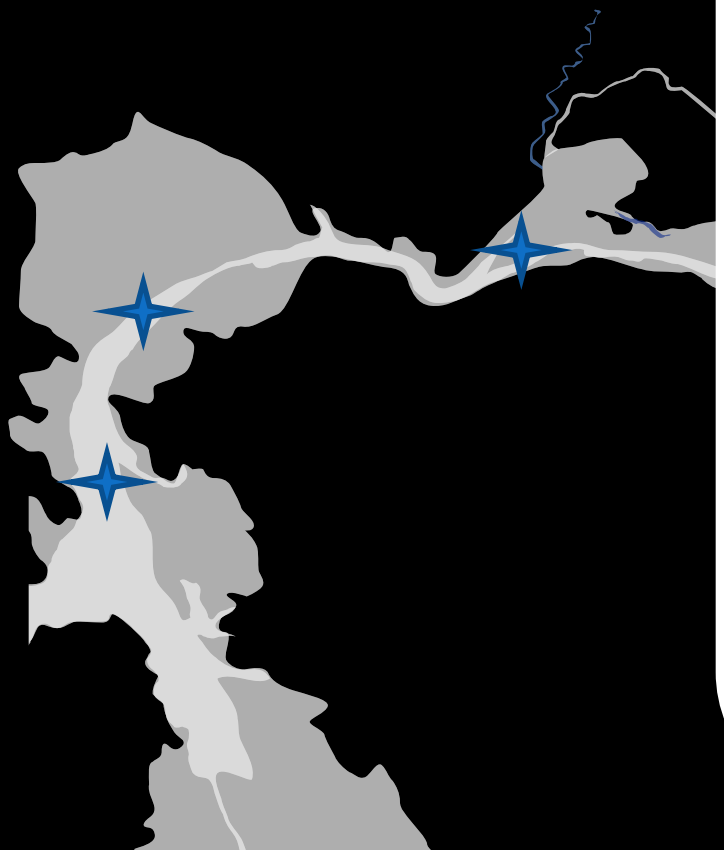


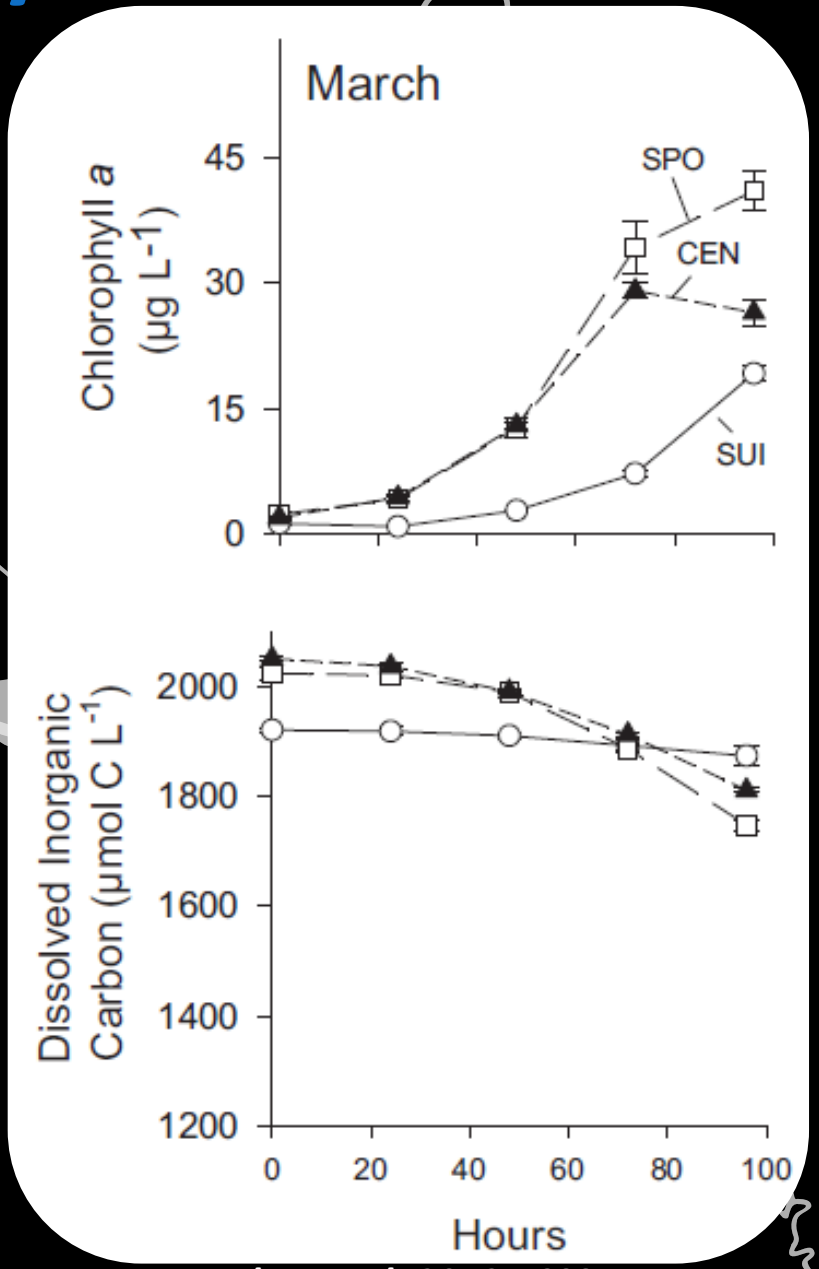


Nutrients and Primary Production in the Delta

Nutrients and Primary Production in the Delta

Chlorophyll-a is dominated by diatoms





From Parker et al. 2012 ECSS

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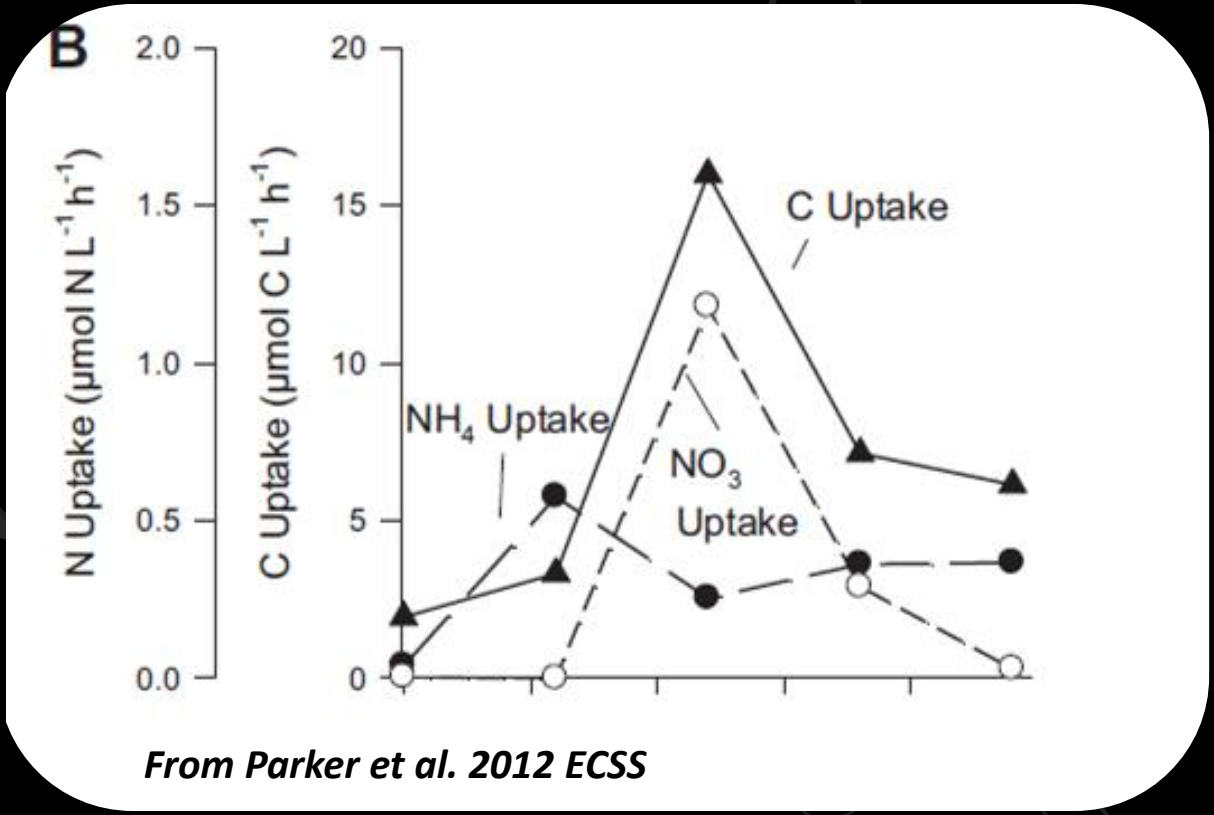

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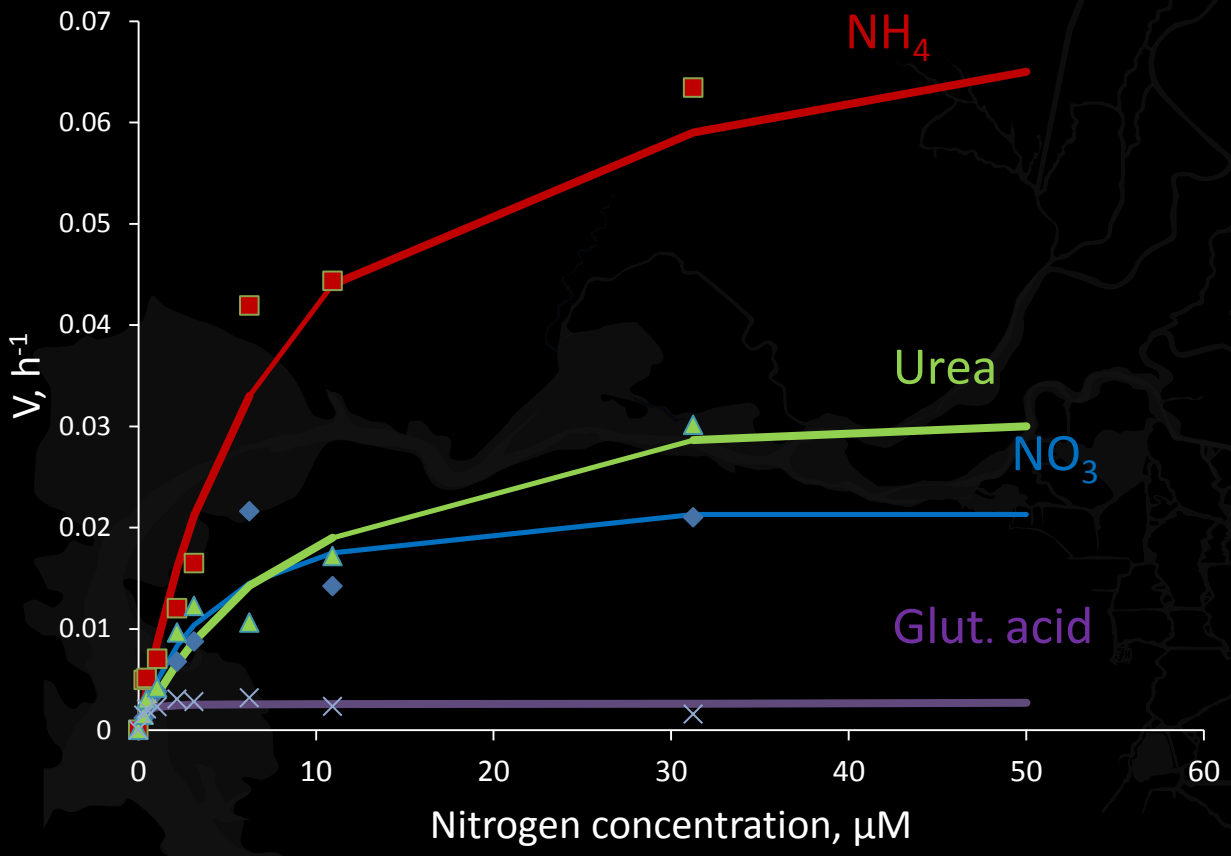
Nutrients and Primary Production in the Delta – *Microcystis*



J. Lee, in prep.

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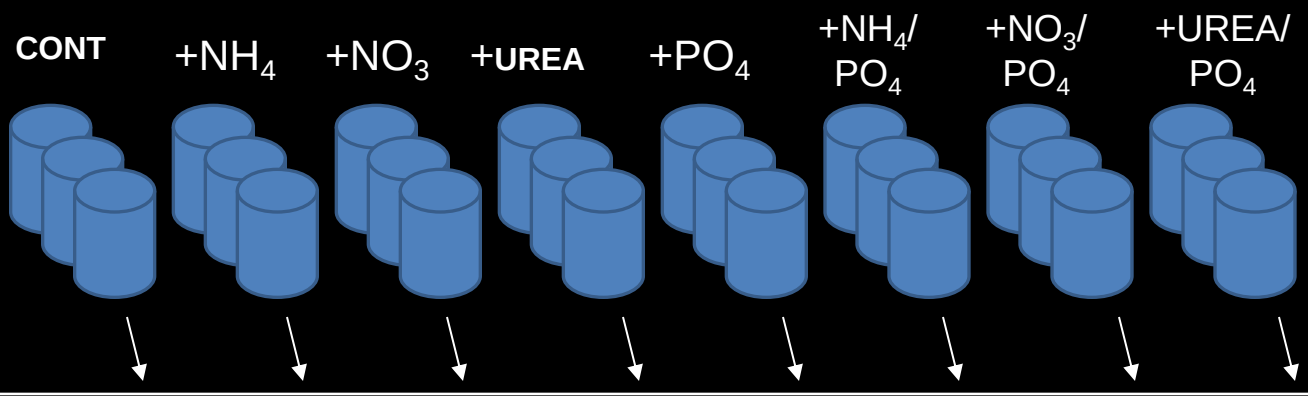

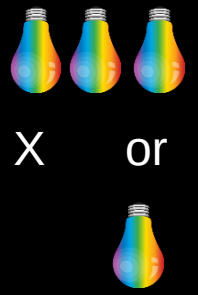

N, µM	5	30	30	30	4	30	30	30
P, µM	2	2	2	2	5	8	8	8
N:P	2.5:1	15:1	15:1	15:1	0.8:1	4.4:1	3.8:1	3.8:1

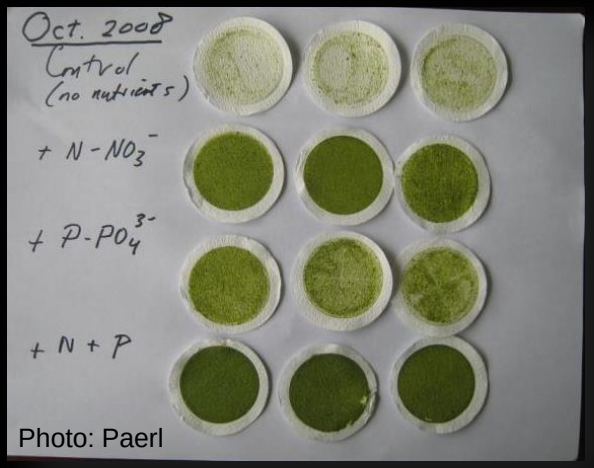

Photo: Paerl

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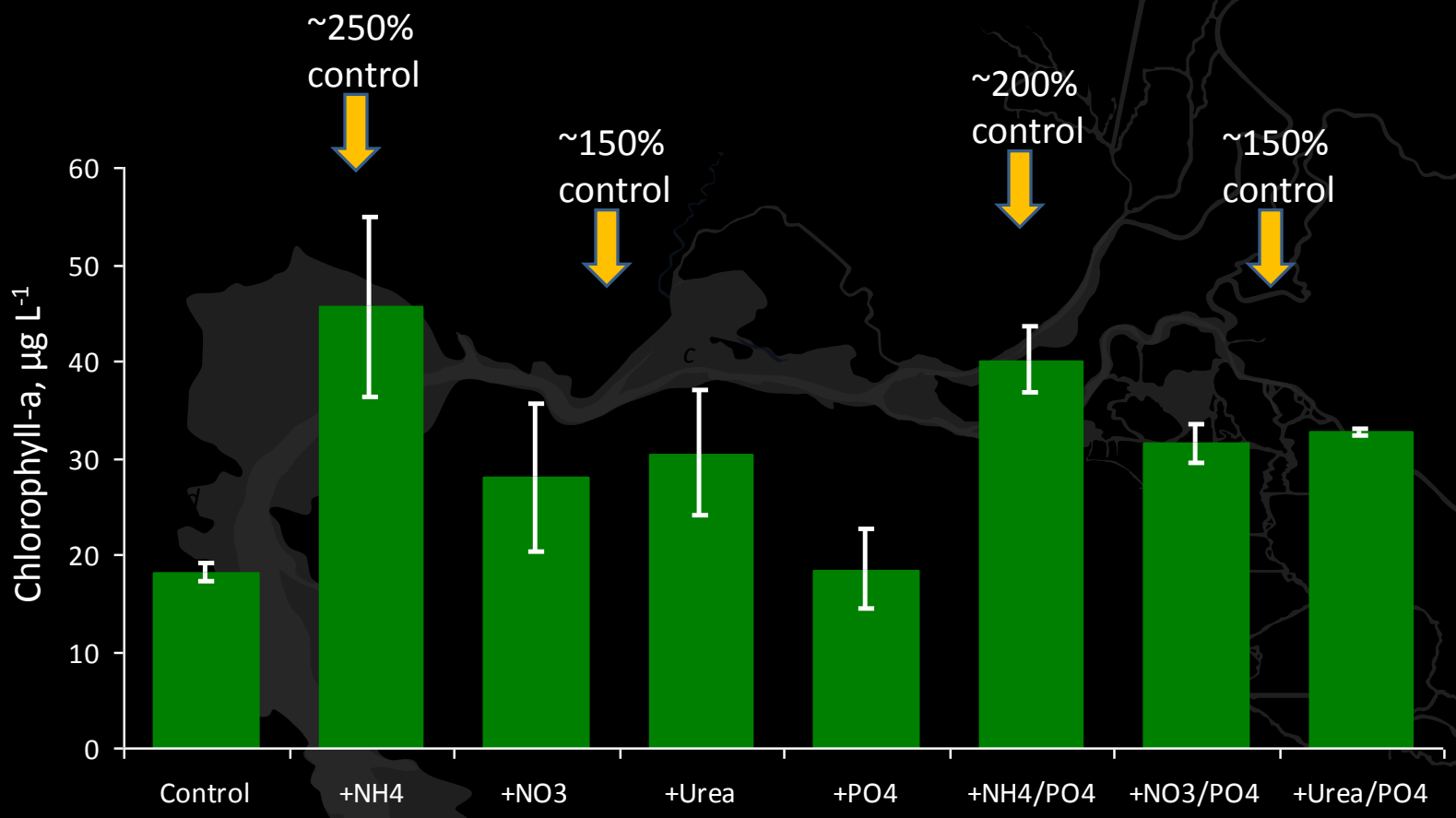
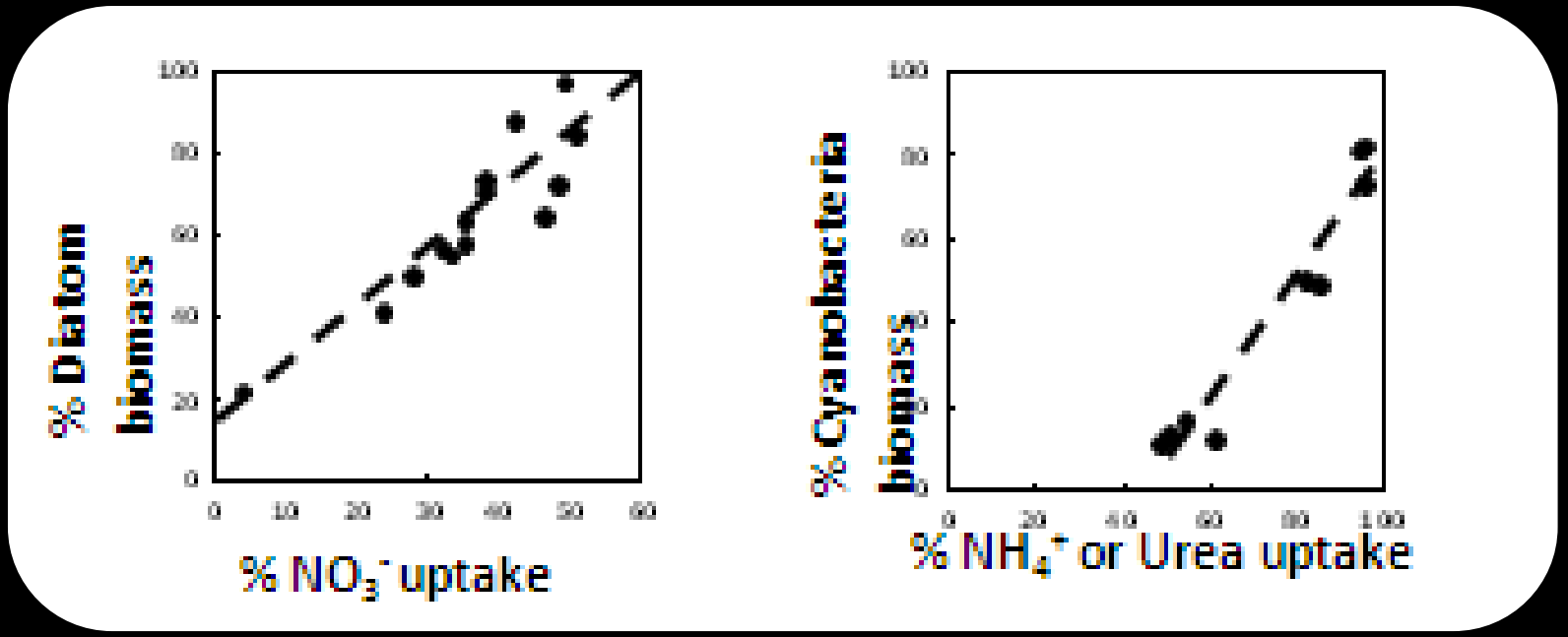


Parker et al. in prep

Nutrients and Primary Production in the Delta



Heil, Revilla, Glibert, Murasko

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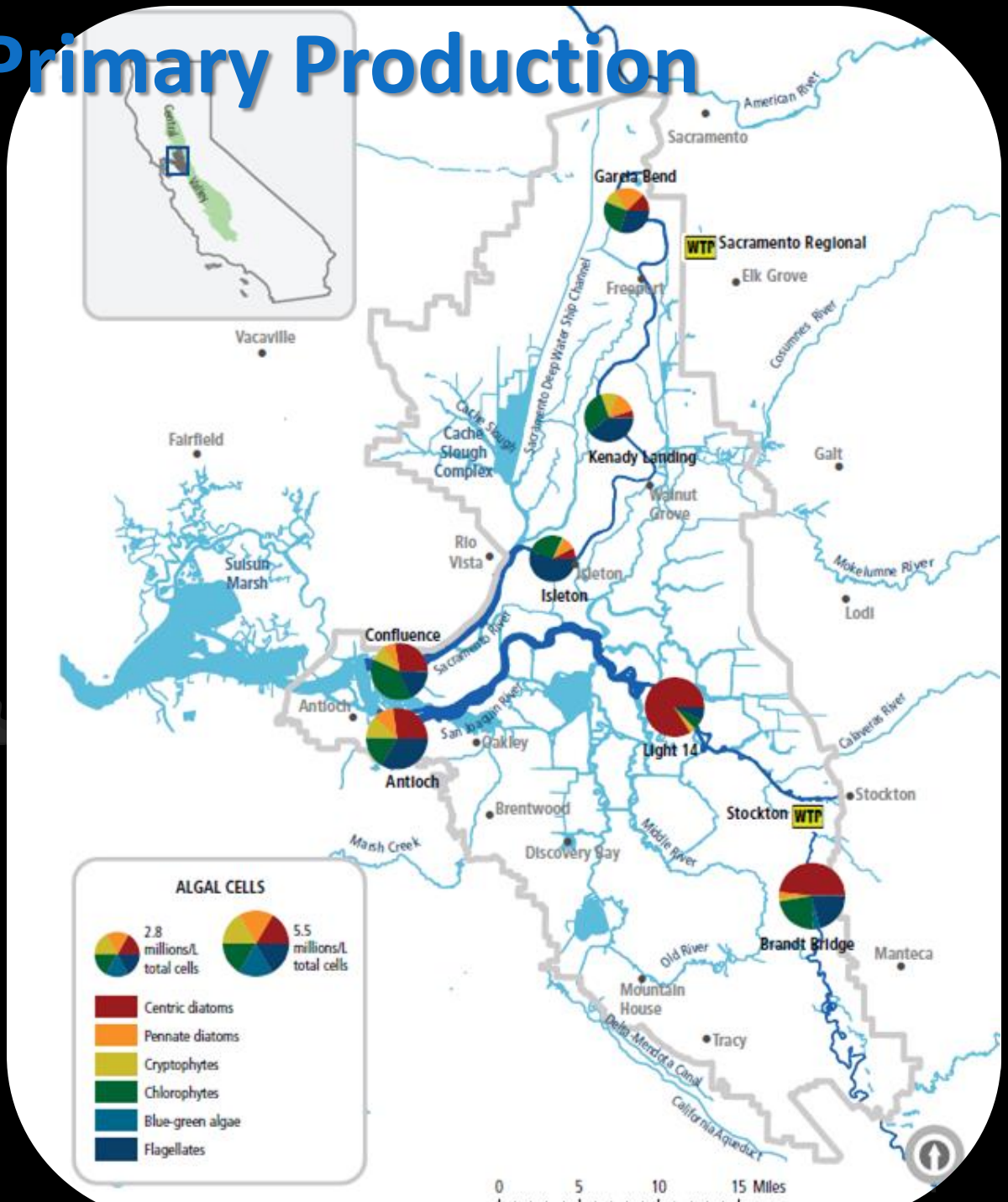

From Pulse of the Estuary 2012; Based on Kress 2012

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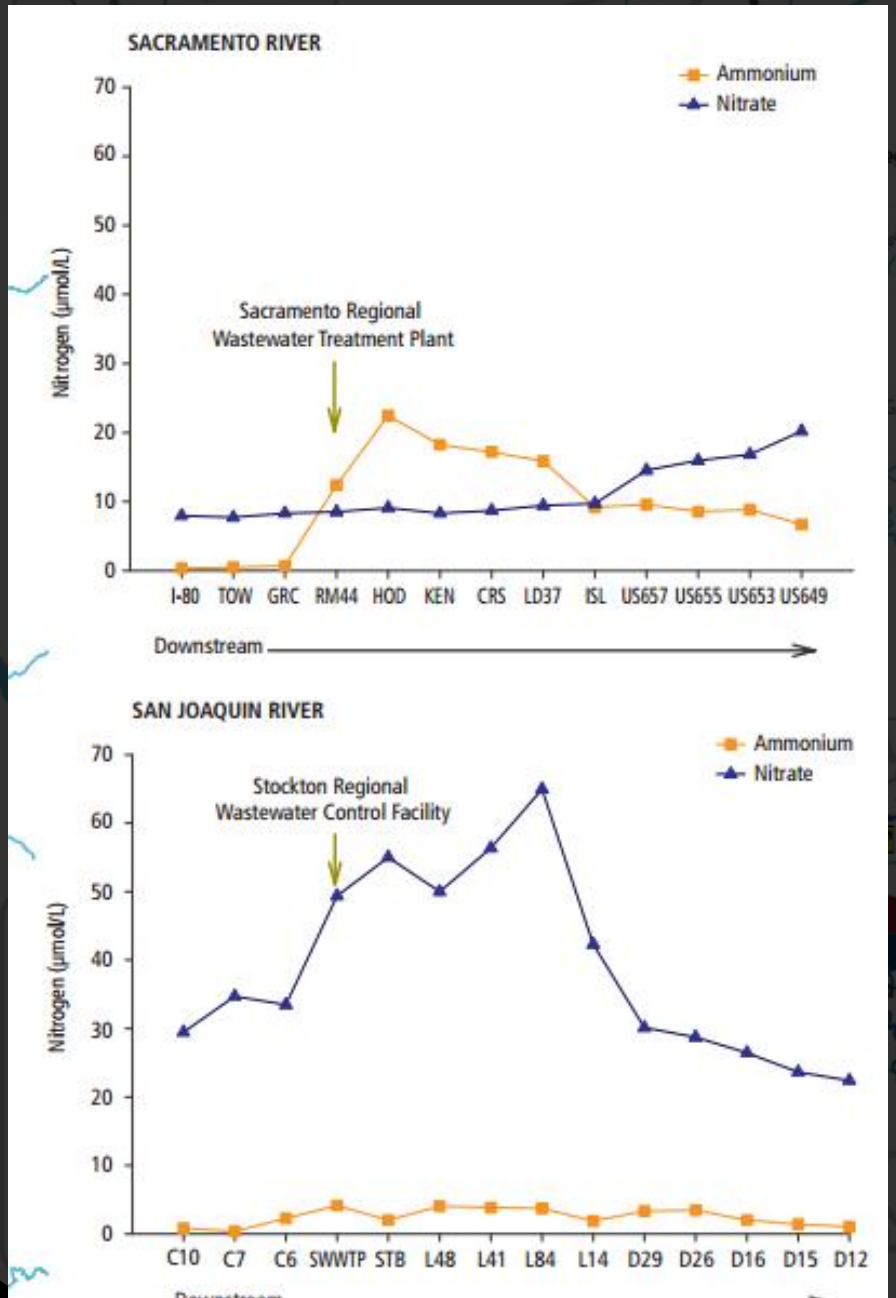

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The Challenge: Placing Experimental Results in an Ecological Framework

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Funding from:
The Delta Science Program
Water Quality Control Boards (R2, R5)
The State and Federal Contractors Water Agency
CA Dept. Fish and Wildlife

Thanks to:
Sacramento Regional County Sanitation District
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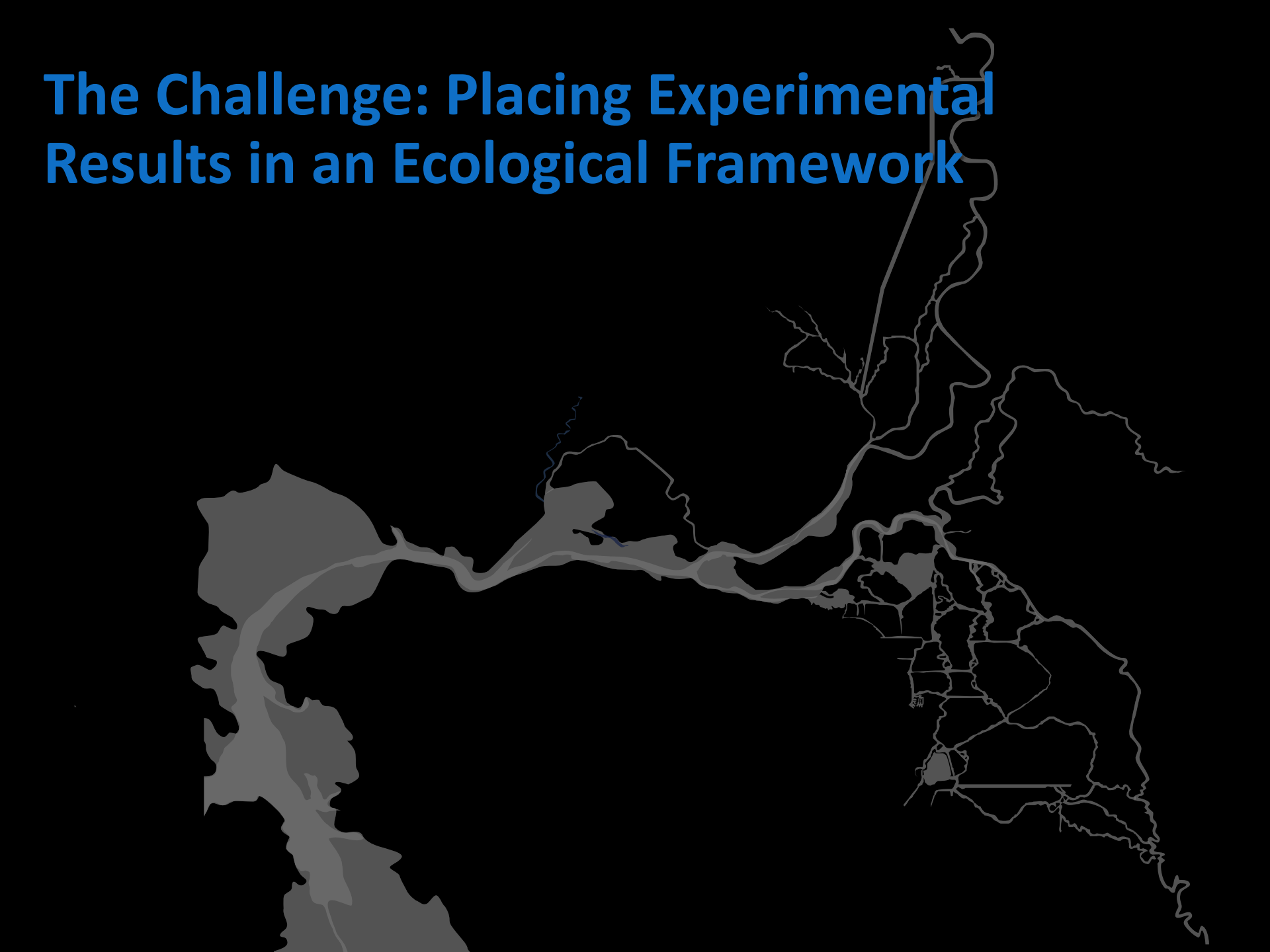
The Challenge: Placing Experimental Results in an Ecological Framework



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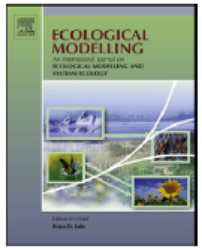

A biogeochemical model of phytoplankton productivity in an urban estuary: The importance of ammonium and freshwater flow

Richard C. Dugdale*, Frances P. Wilkerson, Alexander E. Parker

Romberg Tiburon Center, San Francisco State University, 3152 Paradise Drive, Tiburon, CA 94920, United States